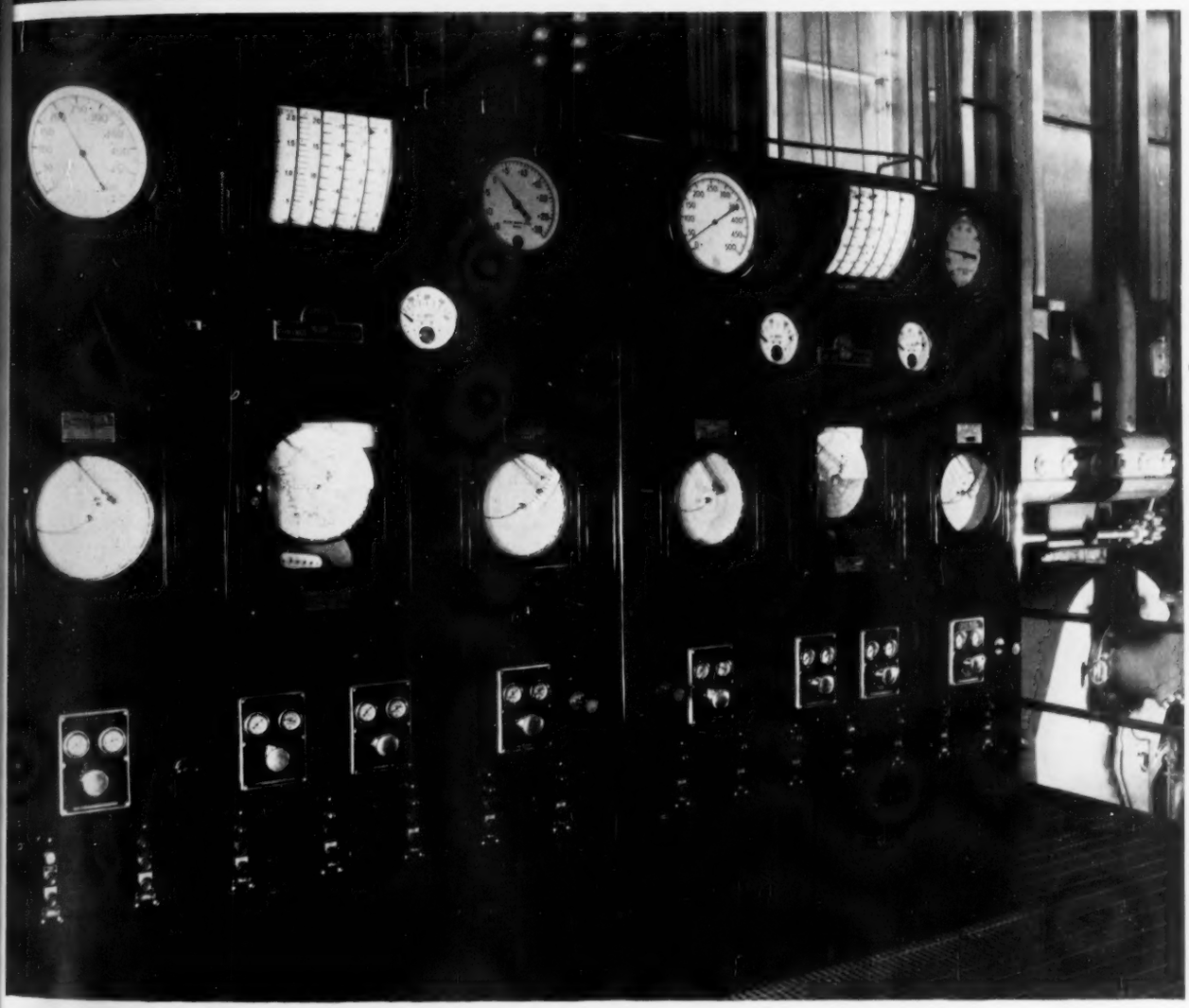
OCT 4 1935

INSTRUMENTS

THE MAGAZINE OF

MEASUREMENT AND CONTROL

Volume 8 OCTOBER 1935 Number 10

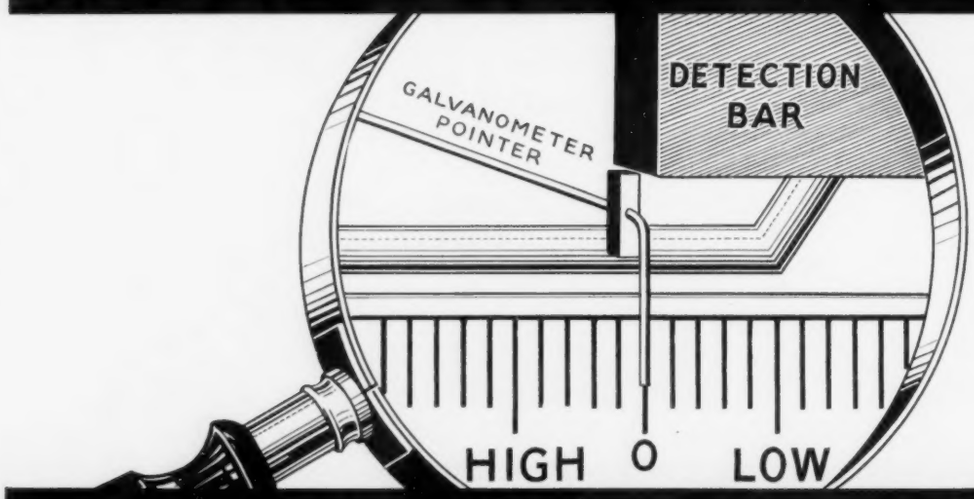


AUTOMATIC COMBUSTION CONTROL—INDIVIDUAL BOILER PANELS

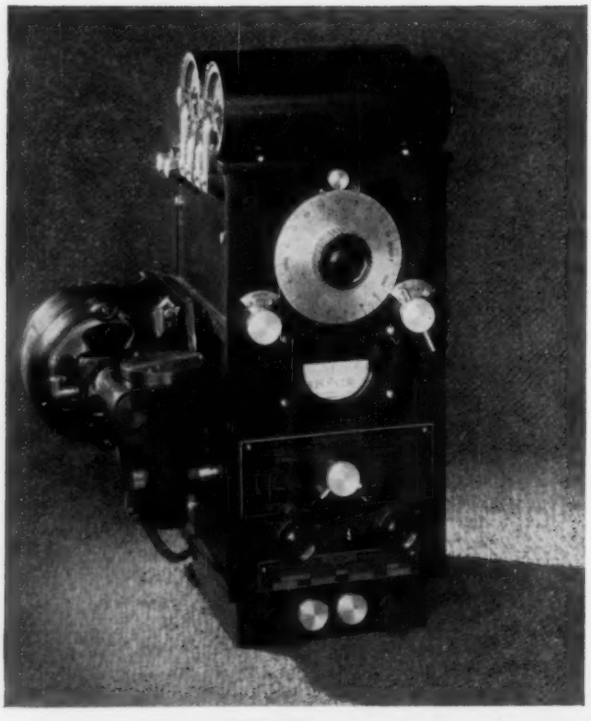
(See article on page 252)

(Courtesy Bailey Meter Co.)

KNIFE-EDGE DETECTION



means *Better Temperature Control*



Unaided eyes can't see a movement of 1/1000th or 2/1000th of an inch. But the acutely sensitive Foxboro Potentiometer Controller can detect this small movement *and exert control action accordingly!* When the temperature in your furnace, kiln or retort begins to vary slightly, the galvanometer pointer of the Controller need deflect as little as 1- or 2/1000th of an inch, to cause the instrument to change the valve setting and restore the control temperature.

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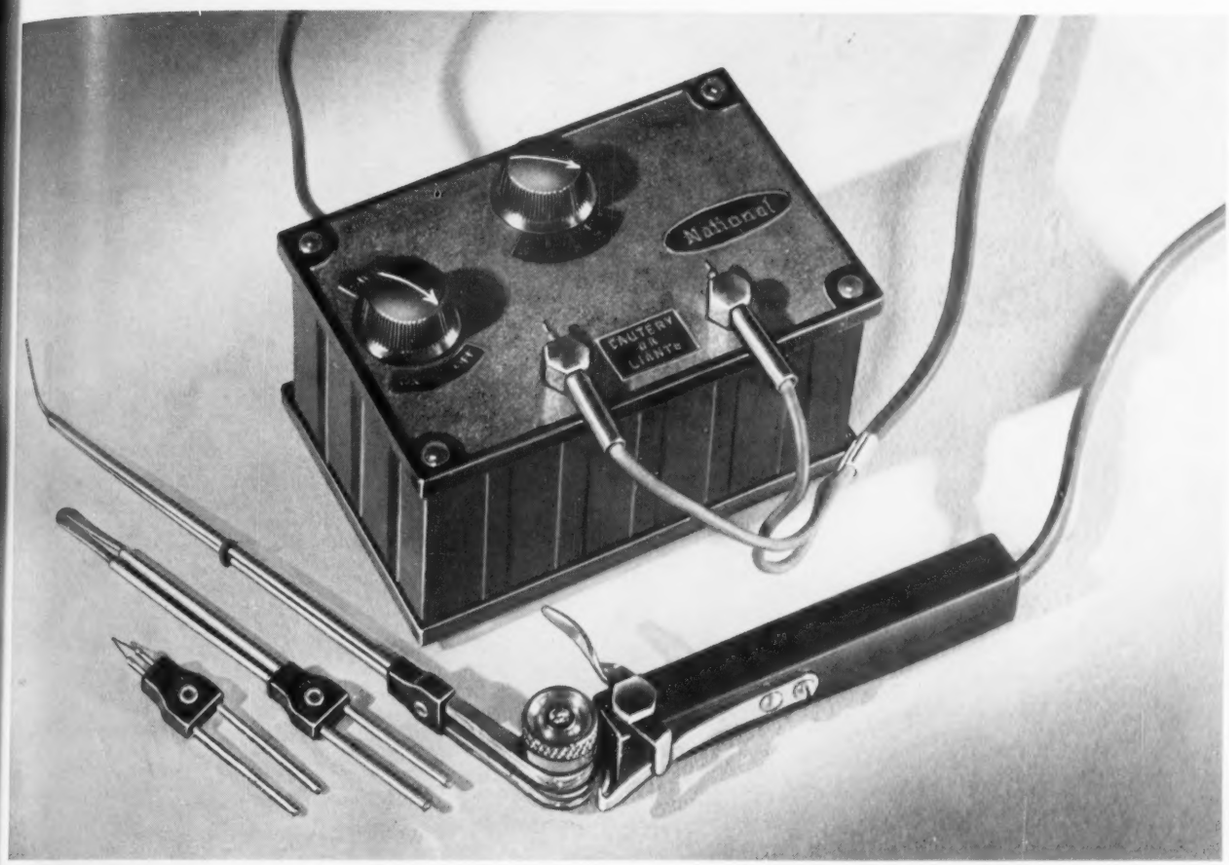

IN THE manufacture of scientific instruments, particularly those designed for the medical and surgical professions, there can be no compromise with dependability. That is why so many leading manufacturers have turned to Bakelite Materials for the construction of their delicate instruments.

The Cautery Set illustrated provides an excellent example of the numerous ways in which Bakelite Materials may be utilized. The transformer box is completely formed of Bakelite Molded in one press operation and the panel top, with relief lettering, in another. The control knobs are produced from this material. Bakelite Molded is also employed for the trigger handle and insulating parts for the doubly reenforced cautery tips.

Bakelite Molded possesses many outstanding properties. It is strong, smooth and hard, is an excellent insulator, and is unharmed by contact with moisture, fumes, oils and most chemicals. Its permanently lustrous surface is easily kept clean and sterile.

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★

Photograph shows Cautery Set made with Bakelite Molded by National Electric Instrument Co., New York, N.Y.

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THE MATERIAL OF A THOUSAND USES

INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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Courtesy Bailey Meter Co.

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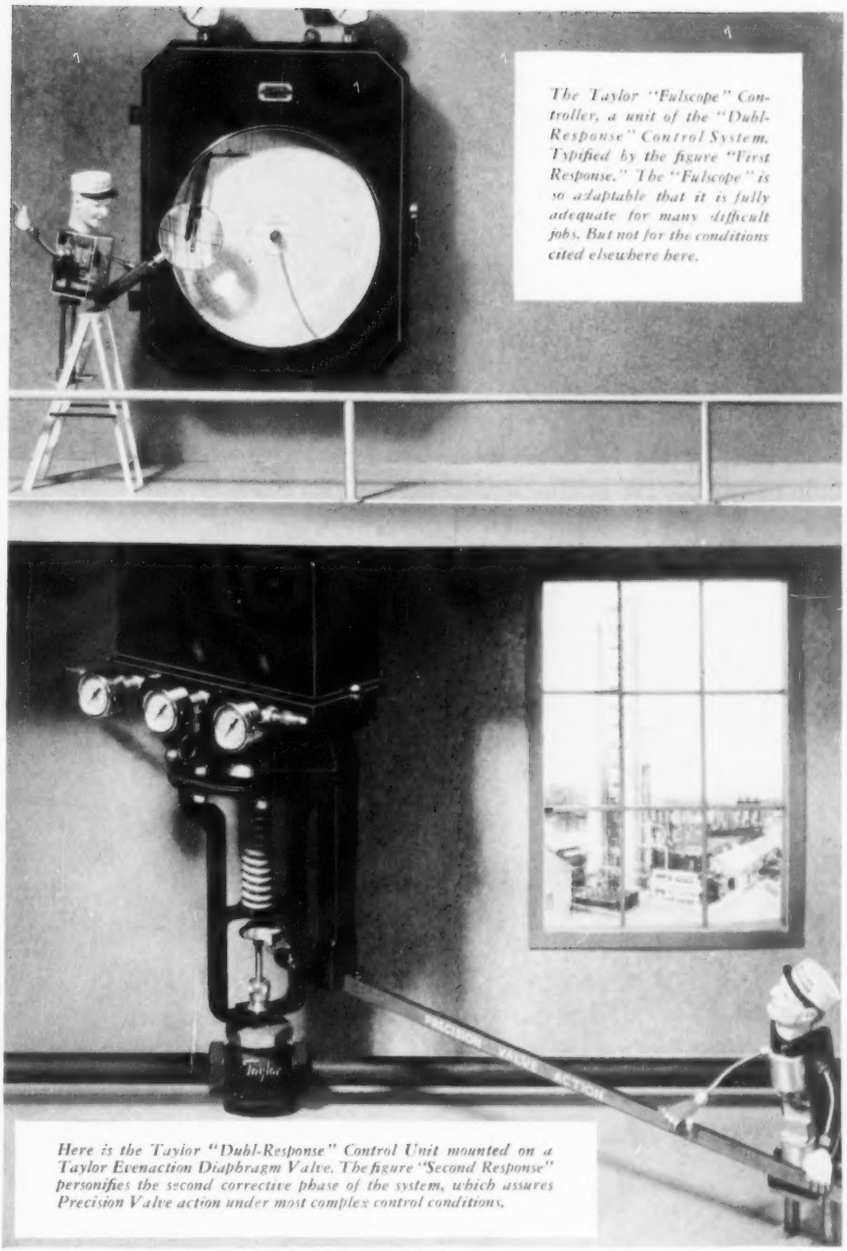
COMPLEX CONTROL JOBS *made easy* by New Taylor "Dubl-Response" System

Industry can now have precision control of temperature, pressure, rate of flow, or liquid level, where ordinary control measures have proved inadequate



The Taylor "Fulscope" Controller, a unit of the "Dubl-Response" Control System. Typified by the figure "First Response." The "Fulscope" is so adaptable that it is fully adequate for many difficult jobs. But not for the conditions cited elsewhere here.

Here is the Taylor "Dubl-Response" Control Unit mounted on a Taylor Evenaction Diaphragm Valve. The figure "Second Response" personifies the second corrective phase of the system, which assures Precision Valve action under most complex control conditions.

THIS new Control System has been termed the most amazing development in the history of process control." In the petroleum field, the dairy industry, and in many branches of the chemical industry, it is revealing its value in performing automatically and instantly unusual feats of control.

The Taylor "Dubl-Response" Control System is most frequently required on continuous processes. It is often necessary on batch and semi-batch processes. It is essential on applications involving *large* process time lags, *even though the load changes are small* . . . on applications involving *moderate* process time lags, if the load changes are *large and frequent* . . . and where time lags and load changes may be comparatively small, but the medium being processed requires the highest possible degree of control.

The complete Taylor "Dubl-Response" Control System is composed of a Taylor Fulscope Controller, and the Taylor "Dubl-Response" Control Unit mounted directly on a Taylor Evenaction Diaphragm Valve. This feature is of extreme importance when close control is required, since it is by this location that *precision valve action is obtained.*

With this new system a control valve of almost unlimited size may be handled. An infinite number of control ranges are available. Sensitivity adjustments can be made on the spot—*immediately*—without shut-down—to meet any control problem. The control point is retained, reguardless of the demand on the controller. Precision Valve action is a certainty.

Let us help you apply the Taylor "Dubl-Response" Control to your most difficult problem. Its adaptability is practically unlimited. SEND FOR TAYLOR BULLETIN 37R, which presents the fundamental facts about process control and tells in detail where and how the Taylor "Dubl-Response" control system fits into the picture. Then ask a Taylor Representative to *help* you decide whether you can apply this remarkable control in your plant. Write Taylor Instrument Companies, Rochester, N.Y. or Toronto, Canada. Manufacturers in Great Britain: Short & Mason, Ltd., London.

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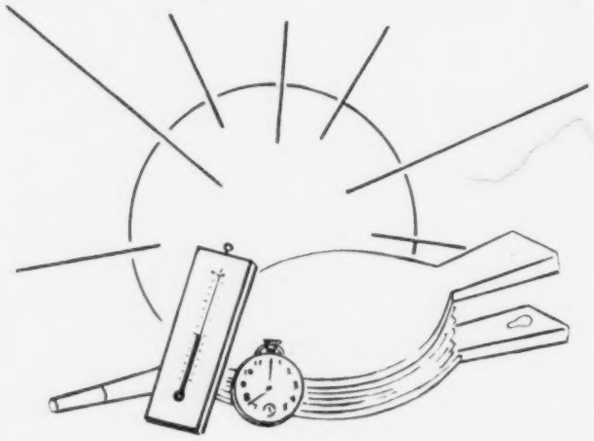

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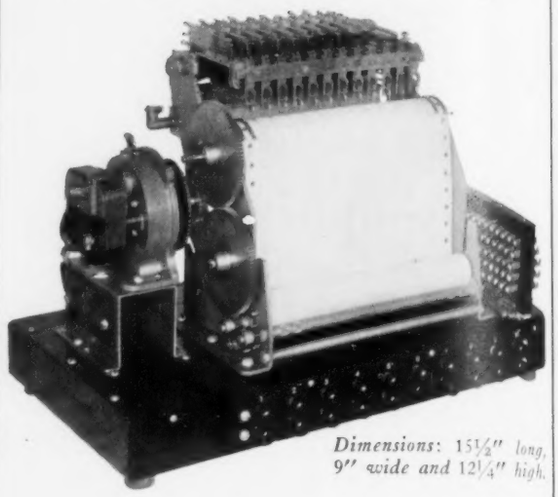

Dimensions: 15½" *long*, 9" *wide and* 12¼" *high.*

This new instrument records twelve separate operations—simultaneously

With the *Autelco Multiple Pen Recorder* you can find out *exactly* what is happening in your plant. It takes all guesswork out of studies of every type by recording, simultaneously, twelve separate curves on the same paper chart. The curves are recorded in ink by twelve pens individually controlled by small, compact magnets operated electrically.

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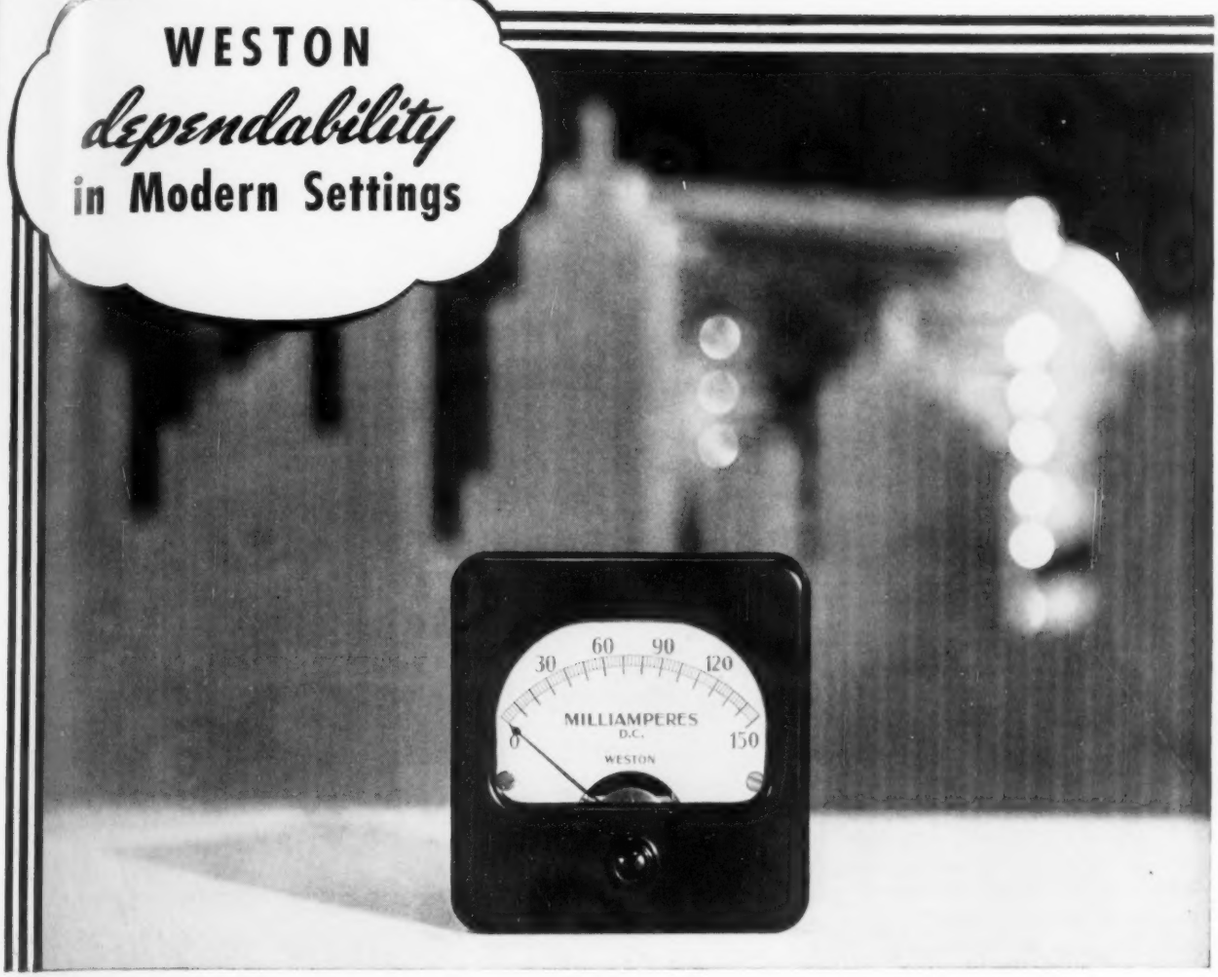

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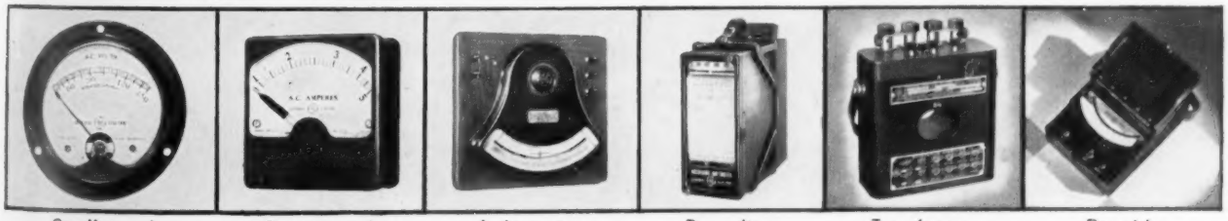

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Big Saving to Small Groups, Too. The original Group Plan was "one for $2, two for $3, three for $4," etc. Your attention is invited to the fact that the *new* Group Plan makes it possible for you to save *more* money beginning with a *two-man group*. Here are the details:

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For each additional subscriptions add	$1.00	$1.00

A Good Deed. No one needs to "sell" you on *Instruments* and you know that your friends will like its exclusive articles and serials, its "New Instruments" and "Inspection and Testing" Departments, the book reviews by famed engineers, the editorials by Major Béhar, the Buyers' Guide, etc. Nevertheless you may want to know whether we have enough copies left of the June issue containing the 20,000-item *Instruments Index*. The answer is yes, but don't delay getting started! Make sure that *your* friends will get this valuable reference. If you want the June issue included, write "June" in margin.

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In This Issue

The usefulness of this month's first two articles is immediate rather than remote: both authors answer in advance numerous questions which would occur to readers desiring to carry out their ideas.

In this respect, W. F. Biggs' article is a full description of a "100% automatic" combustion control installation—all in two pages!

And R. C. Wenz tells "what, how, where, why and who," so that you can almost immediately specify all items required for installing counters and outage-time devices on your conveyors and other plant applications. (Note. For this article we are indebted to J. W. Hicks, Editor of *Byllesby Management.*)

In this month's instalment of our electrical measurement series the "voltage" systems of telemetering are discussed. Important among these is the thermal-converter method. This was originally developed in 1925 under the direction of Perry A. Borden for telemetering and totalizing the 150,000 kw load of the city of Toronto, Ontario, and in the last ten years it has become a favorite of large municipal installations. This is but one of a number of well-known systems and methods of measurement developed by Perry Borden but not commonly bearing the inventor's name.

One more proof that this electrical-measurement series is up-to-date: Fig. 14-18 on page 159 shows a model so new that the photograph could not be taken for us before *October first!* ("Excuse it please" for being unretouched.)

Since many of our readers are interested in vacuum technique we strive to give them an article a year on this topic. L. D. Lockwood not only uses many vacuum gages but requires several types of hot-wire gages; and explains why.

Profuse details are given also by R. R. Batcher in his critical discussions of the many kinds of electrode arrangements for cathode-ray tubes.

And Alexander Smith tells of the surprisingly large amount of research which is being carried on in order that the "juice" won't fail every time there's a lightning storm nearby.

The front-cover photograph is Fig. 1 of W. F. Biggs' article. The Bailey Meter Co. had it taken a few days ago, especially for *Instruments.*

The "Inspection and Testing" Title-page photograph shows the General Electric Co.'s coil-turn counter, capable of counting >40,000 turns, the maximum error being <0.5%.

Advancement

IN these days of stress and strife and struggle, it is highly improbable that many industrial executives and engineers subscribe to technical journals out of curiosity, and read them as a pastime. In the case of *Instruments* there probably is not a single subscriber who does not look upon his subscription as an investment—an investment which yields dividends in the shape of ideas worth money to him.

"An investment which yields dividends" . . . Sweet-sounding words! Sweeter still is the fact that such dividends are frequently worth more in times of depression, for it is then that competition is fiercest among industries, among firms, among departments and among individuals. It is then that Instrumentation is most earnestly called upon to effect economies, to raise quality standards, to commercialize the results of laboratory research, to make possible continuous automatic control of processes. It is then that Instrumentation most dramatically enables industries not only to survive but to prosper; individuals not only to keep their jobs but to advance.

As a subscriber you receive regular monthly dividend checks: you are now holding one in your hands. But do you make it a practice to cash these checks for their utmost value? This question may seem impertinent, but in the course of recent trips we met old subscribers who had got into the habit of "cashing" only one or two regular features of *Instruments*—disregarding the others. Each of these men asked us a question; each of these questions had been answered in a recent issue. Moral: don't skip any department. No doubt, you already are a devoted follower of "New Instruments" but do you likewise scan "Manufacturers' New Literature" and the "Book Shelf"? Use a pad and pencil (or mark the margin) and *follow up* every likely lead. This is the way to get the full value of your monthly dividend check.

One good thing about the science of Instrumentation is its universality. For example, the ideas given by R. C. Wenz in his traffic-counting article are applicable to factory production, and as a result of our publishing this article they *will* be applied in industrial plants where *Instruments* is read; and the production men who introduce them will be advancing (some, we hope, will win promotions immediately). And so on.

But no matter how generously our authors disclose ideas, you can't receive them and cash them if you only read the headlines. No matter how rich the ore of our "New Instruments" and other departments, you can't obtain the pure metal without digging and refining!

There is no royal road to advancement.

M. F. BEHAR

Automatic Combustion Control at the World's Largest Distillery

By W. F. BIGGS
POWER ENGINEER
Hiram Walker & Sons, Inc.
Peoria Illinois

A POLICY which takes full advantage of continuous and automatic operation in mechanical, electrical and chemical engineering is an important factor in maintaining the enviable position of Hiram Walker & Sons, Inc., in the distilling field. Evidences of this policy are to be seen throughout our company's new distillery at Peoria, Ill., "The Largest Distillery in the World"—especially in the boiler room, where both of our 180,000 lbs./hr. capacity boilers operate entirely automatically. These are pulverized-coal-fired B & W boilers of the Stirling type, baffled for three passes and equipped with Sturtevant forced and induced draft fans, Ljungstrom air heaters, Bailey water walls, and Diamond soot blowers. They furnish steam at 230 lbs./in.^{2}, 100° F. superheat, for two G.E. 1500-kw. turbo-generators which bleed at 75 lbs. gage and exhaust at 15 lbs. gage to furnish process steam for cookers, stills and dryers.

Since our normal steam requirements are approximately 240,000 lbs./hr. and a minimum emergency flow of 180,000 lbs./hr. is required to avoid loss of material in process, we consider continuity of service to be of vital importance. Automatic control enables us to operate economically and safely for long periods of time with a minimum of maintenance on boilers and auxiliaries. The writer estimates at about 4% the increased efficiency due to automatic combustion control.

All meters, recorders, gages and automatic control selector valves for each boiler are centralized on a panel; and the two panels placed side by side, as shown in Fig. 1.* This arrangement provides the boiler operator with easy access to complete information concerning boiler performance. Each panel contains a steam flow-air flow boiler meter which also records steam temperature, a multi-pointer draft gage, a boiler drum water level recorder with a supplementary indicating dial and pointer, a feed water meter, a four-pen temperature recorder for the air and the flue gases entering and leaving the air heater, an indicating steam pressure gage, selector valves for the air-operated control system, and electrical push-button stations. These instruments and panels, the master panel, and the associated control equipment, were furnished by Bailey Meter Co. The arrangement of this control equipment in our plant is shown in Fig. 2. Its underlying principle is brought out in Fig. 3. This diagram does not illustrate the layout of our plant but is designed to show the method by which fuel and air supplies are controlled simultaneously from changes in steam pressure measured at the master panel, and how air supply

*The front-cover photograph.—EDITOR

M1—Steam header pressure gage
M2—Master steam pressure recorder-controller
M3—Clock
M4—Master selector valve

B1—Steam pressure gage
B2—Combination boiler meter.
B3—Air heater temperature recorder
B4—Multi-pointer gage
B5—Water level indicator
B6—Feed water meter and drum level recorder
B7—Selector valves for fuel, forced & I.D. fans, and I.D. damper

F1—Drum resistor
F2—Drum resistor drive
F3—I. D. damper drive
F4—From averaging relay
F5—From steam pressure element
F6—From steam pressure element
F7—From furnace draft directly to diaphragm

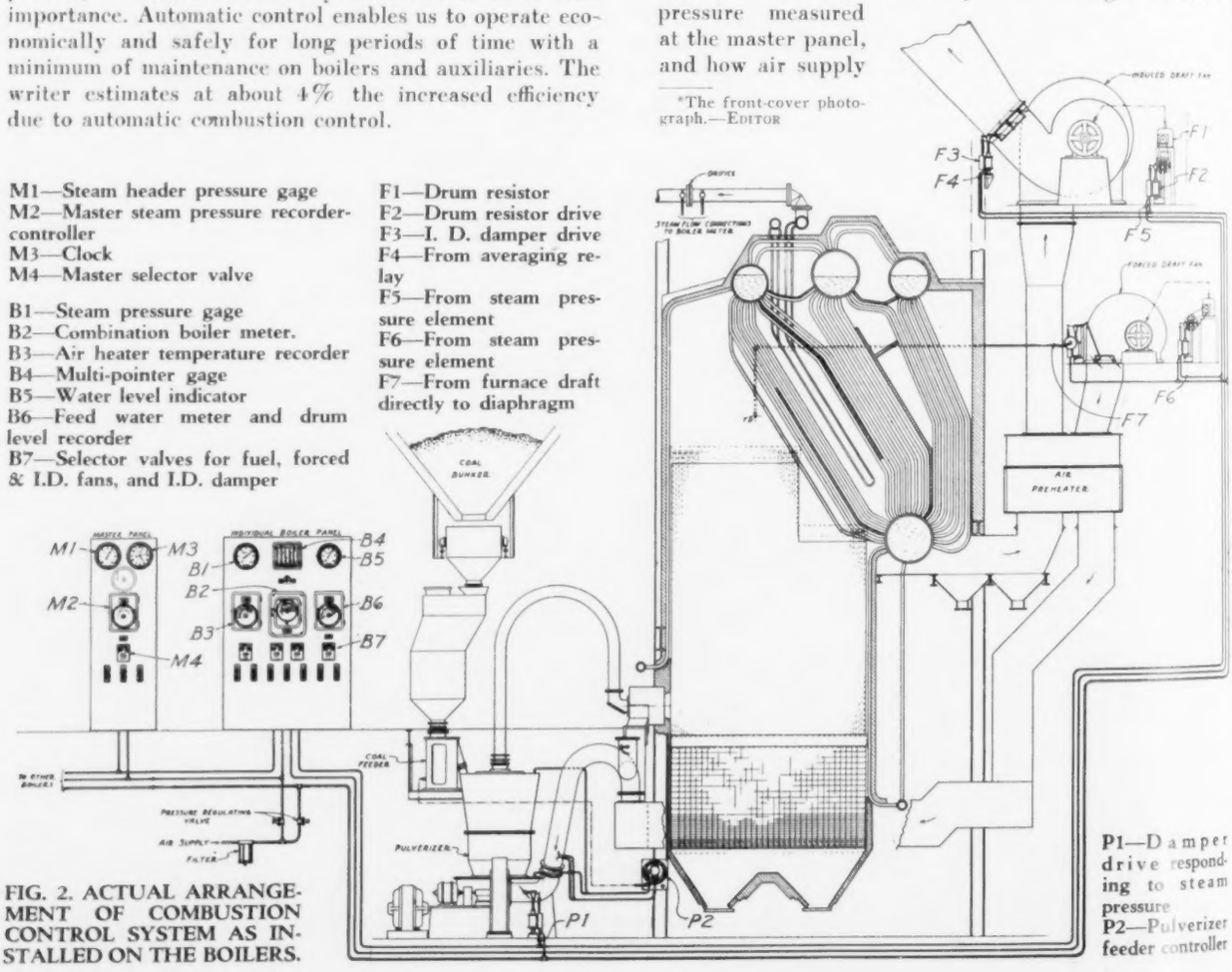


FIG. 2. ACTUAL ARRANGEMENT OF COMBUSTION CONTROL SYSTEM AS INSTALLED ON THE BOILERS.

P1—Damper drive responding to steam pressure
P2—Pulverizer feeder controller

to each boiler is readjusted, as necessary, in accordance with the steam flow-air flow relation at the individual boiler panel.

A master pressure controller (*M2* in Fig. 2) is connected to the main steam header. Its helical pressure spring actuates the master pilot valve which is supplied with compressed air at 35 lbs./in.^{2}. As the demand for steam increases or decreases, a momentary pressure change occurs and the master air pilot valve proportionately increases or decreases the air pressure to each of the individual boiler panels. This "loading pressure" is transmitted through the master selector valve *M4*. At each individual boiler panel the loading pressure is directed through two different paths, as clearly shown in Fig. 3. One path is through the averaging relay and through the uptake draft selector valve to the uptake draft servomotor or "control drive" (*F3* in Fig. 2). The other path is through the primary air selector valve and thence to *both* the primary air control drive *P1* and the forced draft fan control drive *F6*. (In Fig. 3 the latter is omitted for the sake of simplicity.) At each of these control drives the controlled air pressure is applied to a small metal bellows which actuates a pilot valve to admit full-pressure compressed air to one side or the other of the power piston, until the position of the damper or other device under control has been altered as required.

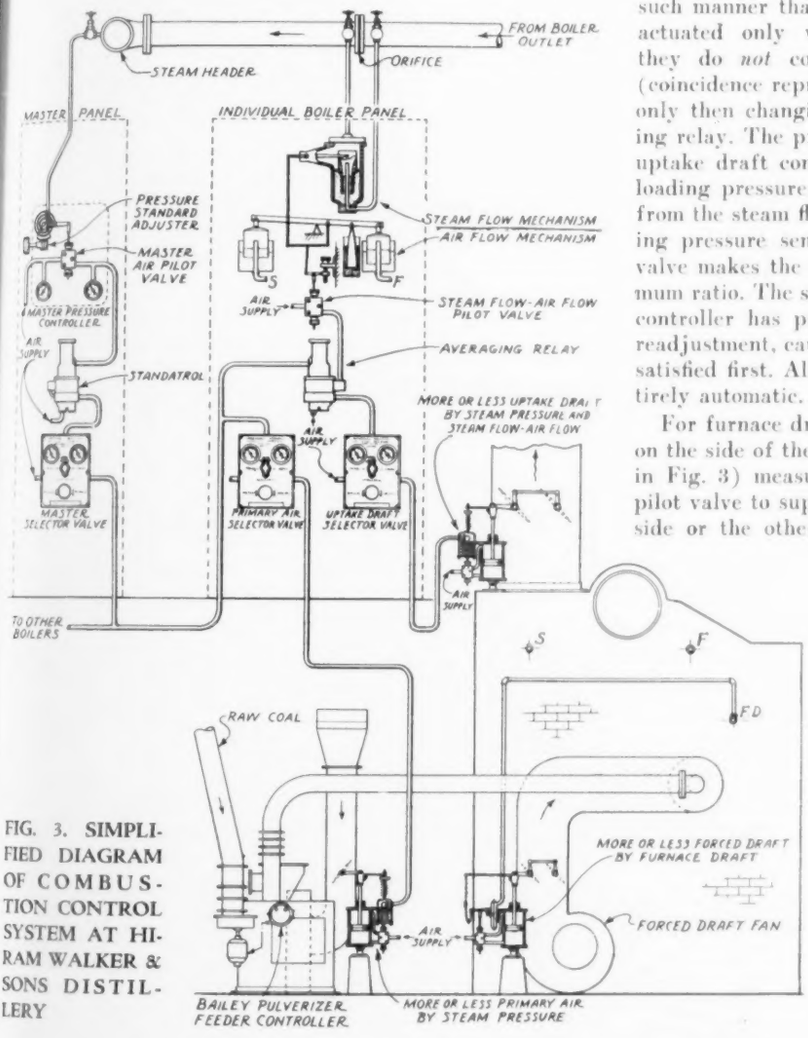


FIG. 3. SIMPLIFIED DIAGRAM OF COMBUSTION CONTROL SYSTEM AT HIRAM WALKER & SONS DISTILLERY

The rate at which raw coal is fed to the pulverizer is controlled by the Bailey pulverizer feeder controller *P2* to maintain the correct level of coal for the required output.

Fig. 4

After an initial change in fuel and air supply has been made, it may be necessary to readjust the air slightly to maintain correct fuel-air ratio for efficient combustion. This readjustment is accomplished automatically at each boiler meter, in which a pilot valve is connected by a linkage to the steam flow and the air flow pens in such manner that it is actuated only when they do *not* coincide (coincidence represents optimum combustion conditions), only then changing the loading pressure to the averaging relay. The pressure *from* this averaging relay to the uptake draft control drive is the algebraic sum of the loading pressures it receives from the master pilot and from the steam flow-air flow pilot. Thus a change in loading pressure sent out by the steam flow-air flow pilot valve makes the uptake draft control drive restore optimum ratio. The sequence is such that the master pressure controller has precedence over the steam flow-air flow readjustment, causing the steam pressure condition to be satisfied first. All of these operations, of course, are entirely automatic.

For furnace draft control, a large diaphragm mounted on the side of the forced draft control drive (lower right in Fig. 3) measures furnace draft and actuates an air pilot valve to supply full-pressure compressed air to one side or the other of the piston. The piston movement varies the slack of a chain, adding or subtracting weight until the pilot valve is again at neutral.*

References have been made to control drives. These, as was brought out, are all pneumatic. Fig. 4 shows the installation of the one which operates a Westinghouse drum controller for regulating the speed of a forced draft fan.

We find that the arrangement described (a master selector valve and individual selector valves for the fuel, forced and induced draft fans, and for the induced draft damper) gives us highly flexible utilization of the control system. By "flexible," the writer means that our arrangement permits the entire plant or the individual factors to be under complete automatic, partial automatic or manual control from the panel board as desired. Automatic combustion control safeguards our Company's investment in boilers, in water walls, in pulverizers and other burning equipment, in preheaters, etc., by operating all this modern equipment at design conditions.

*This diaphragm-and-chain arrangement evidently is something new, just brought out by the Bailey Meter Co. We hope to be able to publish a description of it in next month's "New Instruments" Department.—EDITOR

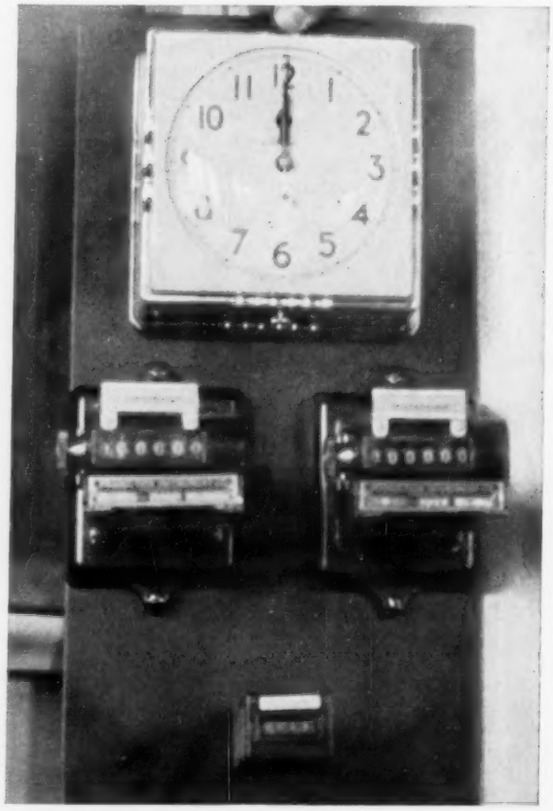
Photoelectric Instruments Count Vehicles Crossing Cairo (Ill.) Toll Bridge

By RUSSELL C. WENZ*

FOLLOWING up an inquiry from the Cairo Bridge Co. concerning rubber insulated control cable, it was learned that, with the cooperation of the manufacturer of a fare register, officials of the bridge wished to obtain a counter of tolls sufficiently automatic in operation to signal the amount of toll registered at the toll house to an inspector stationed at the opposite end of the bridge. At a conference with these officials it was recommended that an investigation be made of the possibility of using a photoelectric cell device to count the cars crossing the bridge. They requested and authorized such an investigation.

As far as could be determined from representatives of the General Electric and Westinghouse companies, no equipment involving the use of photocells had been used outdoors for this purpose. The problem, therefore, was an extremely interesting one because of the many difficulties involved. To begin with, the cost of the equipment must be fairly low in order to make it economically possible to warrant its use. A study of the requirements brought out that it would be necessary to project several beams of light across the bridge roadway and that these beams would have to be about 60" apart, so that automobiles with a short wheel base could not pass the lights without intercepting the beams simultaneously. At the same time, it was desirable that the beams be separated as far as possible so that an extra count would not be made of small trailers drawn by passenger cars. More than one beam had to be used, so that pedestrians would not cause a registration on the counter. A survey at the bridge revealed that the north-bound cars traveled as fast as 35 miles per hour at the point where it was intended to locate the equipment. This meant that the cars traveling at this speed crossed the intended counting area in approximately 0.1 sec.

The reasoning for considering several beams of light was that the traffic was not directional; that is, north-bound cars were not segregated from south-bound cars, so that the position of the car in the roadway did not necessarily indicate its direction.



Panel in toll house. Top—Outage time indicator. Center—Counters for north-bound and southbound traffic. Bottom—Outage number counter.

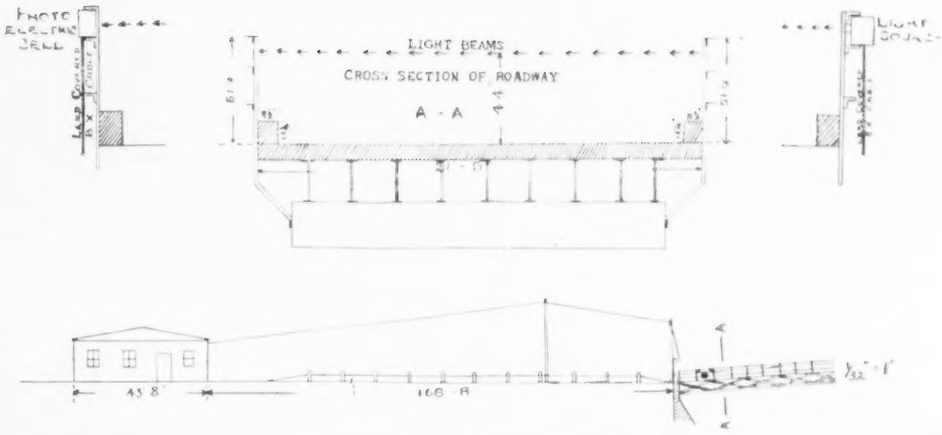
Quotations were taken from manufacturers on a four-beam equipment—two beams to register the cars moving in one direction and the other two for those moving in the opposite direction. In going over these bids with the manufacturers, the idea was developed that if the design could be changed to two-beam equipment the cost could be cut about 50%. While the hazard of cars passing the two beams of light simultaneously was slightly increased, it was decided to use a two-beam equipment because an error could only be caused in the short interval of a fraction of a second and only by cars moving in opposite directions.

The light sources are installed on 60" centers at a height of 44" above roadway floor elevation. They are mounted in such a manner that the beam is projected horizontally across the roadway at an angle of 20°. This angle prevents reestablishment of the beam between the rear of the car and a spare tire, trunk or other projection which could re-interrupt the beam and cause false counts to be made. The 44" height was determined in the field after a survey of the traffic crossing the bridge during the time that the equipment was being installed. It is advantageous to have the beams this high, in order to avoid the possibility of "shooting" under the bodies of large trucks and also to stay clear of wheel spokes which, if high enough to intercept the beams, would cause false registrations.

The fact that horizontal beams were decided upon necessitated placing the equipment where it could easily be tampered with. While the light sources and phototubes were enclosed in weather-proof cases, which are padlocked and thus protected, there remained the possibility that some one might try to render the equipment inoperative by blocking the light sources or the aperture of the phototube housing. In order to cope with this possibility, there were installed in the counter cabinet in the toll house, three devices which become involved if the equipment is rendered inoperative by the external blocking just mentioned or because of the failure of one of the vacuum tubes. After an outage of a few seconds, a bell alarm in the counter cabinet is set off and continues to ring until the trouble

*Engineer, Byllesby Engineering and Management Corp., Chicago, Ill.

is cleared and the equipment restored to operating condition. In addition to the bell alarm an outage counter registers the outage. At the same time, a self-starting electric clock, normally set at 12 o'clock, starts to run, thus indicating to the second the length of time that the equipment was out of service. The bell alarm is operated by dry cell batteries, so that it rings even when the a-c. supply has failed. This is done through a current relay, which remains open as long as it is energized and, on failure of the current, becomes deënergized and closes its contacts, causing the alarm bell to operate.



Upper drawing—Cross-section of bridge roadway, showing position of horizontal beams; and details of light-source and photocell. Lower drawing—General arrangement.

An aerial cable extends from the toll house to the bridge, where it enters conduit and passes under the roadway to the relay cabinet which is mounted back of the railing and between the two phototube housings.

In the counter cabinet at the toll house there have been mounted:

Two Production Instrument Co. "EC-9" counters, one for north-bound traffic and one for south-bound traffic.

An Automatic Electric Co. telephone relay, which registers outages of the counting equipment.

A Telechron "2F01" clock to register the time the equipment is inoperative.

One of the problems was to secure a counter which would consume a small amount of current and which could register an impulse and dissipate the residual current in time to register a car closely following another car just registered. We found that the Production Instrument Co. of Chicago had a counter capable of registering 7 impulses a second, and consuming 6 watts: the pick-up current on 115 volts, 60 cycle a.c. is 0.213 amps., and the holding current is 0.130 amps. The question of current consumption is important when the counters are operating on light relays with small contacts which are regularly used in the photoelectric relay equipments of the leading manufacturers—particularly if the counter is connected in plate circuit of Thyratron or similar tubes. There is approximately a 5% differential in the length of time the electromagnet is in the closed position and in the open position. In other words, the time it takes the electromagnet to release, including the dissipation of the residual magnetism and its return to the normal open position, is approximately 5% less than the make time.

Needless to say, without this counter or one with its characteristics, the purpose could not be accomplished. This is also the first time that these counters have been used to count vehicles.

The contract for the photoelectric cells, relays, etc., was awarded to the General Electric Co. Supplemental apparatus was purchased from the following firms:

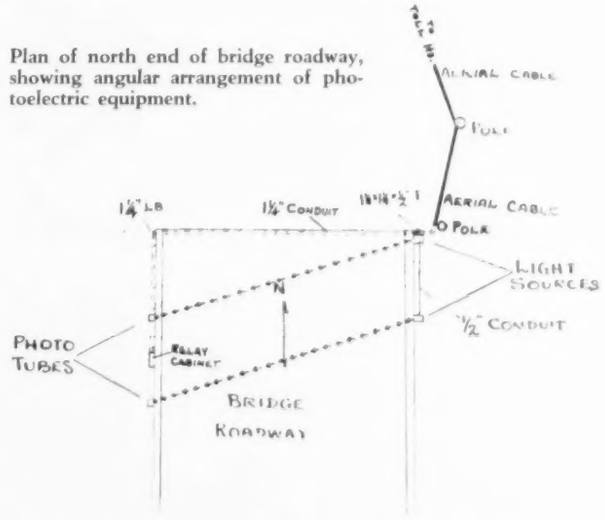
Counter Cabinet—Delta-Star Electric Co., Chicago
Outage counter—Automatic Electric Co., Chicago
Vehicle counters—Production Instrument Co., Chicago
Monitor bell, Telechron clock, conduit and batteries—Graybar Electric Co., Chicago
Aerial cable—Okonite-Callender Cable Co., Chicago
Steel supports for bridge equipment—Vulcan Iron Works, Cairo, Ill.

Up to the present time (Sept. 1935) approximately a quarter of a million vehicles have been counted. During the two-week period covered by a typical toll equipment report, the photoelectric equipment registered 4,068 vehicles and the fare machine 4,051—the maximum differential between the machines was 0.4%. It is interesting to note that only two outages took place during the two-week period and that both of these outages were registered by external causes. The first one was caused by a truck which stopped on the bridge in front of the lights. This caused the alarm bell to ring in the toll house and added one count on the outage counter and started the Telechron clock. The second outage was caused by a man who was painting the brackets on the light sources. The bridge report does not indicate the duration of either outage; however, it is our opinion that neither lasted more than a fraction of a minute.

The average life of the phototubes is 8000 hours. They are watched closely and, if the equipment starts to get sluggish, are removed and held as spares. The equipment consumes approximately 75 watts.

The writer expresses his acknowledgment and appreciation to Captain Hewitt Johnston, superintendent of the Cairo Bridge, and to Mr. William Stout and the toll collectors, for the assistance they rendered while the photoelectric equipment was being installed.

Plan of north end of bridge roadway, showing angular arrangement of photoelectric equipment.



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G-3

BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

Telemetering and Totalizing*

By PERRY A. BORDEN and M. F. BEHAR
Member A.I.E.E. Editor, *Instruments*

(*Continued*)

6. Voltage Class

(a) Principal Features and Characteristics

As its name would imply, the voltage class of telemetering systems employs a principle which consists in (1) producing at the transmitting end of an interconnecting circuit an electromotive force representative of the measured magnitude, and (2) performing measurement on this voltage at the receiving end. As might be expected, there exists a close resemblance between the voltage and the current systems, and it will be apparent that the control and measurement devices used for one system may often be used for the other without material modification.

Voltage Transmitters—General.

The method by which the transmitted voltage is made representative of the measured magnitude depends to a great extent upon the nature of that magnitude. In rectifier systems, such as those briefly discussed under the heading of current telemetering, an a-c. magnitude may be directly converted into a unidirectional voltage; and in the thermoelectric system described below there is effected a double conversion: electrical-to-thermal-to-electrical. Where the measurement as expressed by the primary measuring unit takes the form of a physical deflection of a moving part, conversion of this deflection into a representative voltage may be effected in any one of several ways, the most obvious being in the use of a motor-driven (or, less commonly, a directly-actuated) rheostat or inductive voltage regulator. It also it possible in many cases to make use of electronic circuits, but complications may here be essential in order to render the system insensitive to tube characteristics.

Voltage Transmitters—Electric Tachometers

Special mention must here be made of the electrical remote-reading systems of speed measurement. There are numerous types of these[5] and it has been customary to consider all of them to be electrical telemetering systems. In particular, the familiar system consisting of (1) a magneto generator driven by the machine whose speed is desired to be measured, (2) a high-resistance millivoltmeter for indicating or recording speed, and (3) an all-metallic interconnecting line, is unquestioningly included among "voltage telemeters" by most writers. Their reasons, no doubt, are that the length of the interconnecting line may often exceed one or two miles, and that the electromotive force generated by the magneto is (usually) linearly proportional to the rotational velocity at any moment. These features do not suffice, however, to constitute a telemetering system of the voltage class—or of any class. It was pointed out in Section 1[6] that the systems must include (1) a measuring element at the point of measurement and (2) an element associated therewith converting the measured magnitude into a transmittable magnitude; and in Section 3[6] that the "transmitter" of an electrical telemetering system must in reality be a measuring-and-transmitting assembly. In the familiar remote-reading magneto type tachometer the function of the magneto is not to measure, but to convert a speed into a voltage—just as it is the function of a thermocouple to convert a temperature into an electromotive force.

If, however, this same simple remote-reading system is employed to transmit the result of an antecedently-performed measuring operation, then it becomes a portion of a true telemetering system of the voltage class. There are various

[5]M. F. Béhar. Electric Tachometers. *Instruments*, Vol. 4, Sept. 1931, pages 489-504.
[6](In the August 1935 instalment of this series.)

*Sixteenth chapter (XLIV) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. Each chapter is subjected to a final revision shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up-to-date. This new book is not published serially in any other periodical. Entire contents copyright. To be issued in book form on or about Jan. 1, 1936.

examples of such voltage telemetering systems in which the transmitted voltage, which corresponds to the reading of the primary measuring element, has its source in a small generator whose *speed* is made to be representative of this reading—either linearly, or according to a quadratic or other predetermined relation. As a rule, the simplicity of the ordinary electric tachometer is sacrificed in such systems but its essential principle, though disguised by elaborate devices, remains the same.

The ordinary electric tachometer with a d-c. magneto is subject to the usual commutator-and-brush troubles, and its transmitter requires inspections at intervals which, though long enough for applications where the magneto is accessible, are not tolerable in a telemetering system. For voltage systems employing the tachometric principle, special generators have therefore been designed.

Voltage Receivers—General.

Where a motor-driven regulator is used as the translating device between the measured magnitude and the transmitted voltage, there is little to choose, as far as the transmitter is concerned, between the current and the voltage classes of telemetering systems; but in the receiver the relative simplicity of the milliammeter type of movement generally used with the current system may be offset by the advantages of using a voltage-balancing instrument, whereby the line current is reduced to zero and a precise measurement obtained with a minimum amount of power transmitted in the line. In the thermoelectric system the potentiometer type of receiving instrument is practically essential to accurate results, while the receiving of voltages developed by directly-regulated variable-ratio transformer transmitters presents problems which will be discussed under the corresponding heading.

(b) Voltage-balancing Systems

For reasons made plain in our preceding articles on potentiometer and bridge methods of electrical measurements, minimum current in the interconnecting line is required for attainment of the highest accuracy and utmost reliability of which the voltage system is capable as a *measuring* system; and such minimization of current flow is required also for permitting the use of telephone pairs and for other desirable *telemetering* purposes. Such minimization requires in turn the use of a self-balancing potentiometer as a receiving instrument, and it is logical that the best-known telemetering outfits of the voltage class should be sponsored by the manufacturers of self-balancing instruments.

Moreover, the most obvious application of this principle is to transmit the readings of an existing installation of "servo-motor" or relay types of recording instruments—since these make readily available both the requisite mechan-

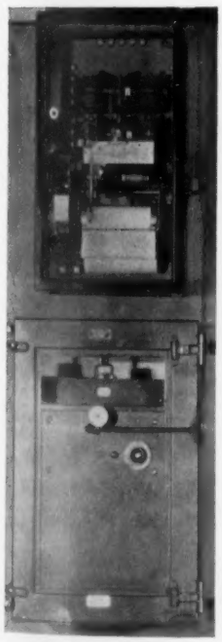

Fig. 44-14

Fig. 44-15

8 Ounces of Gold in Thirty Days

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*Some engineers do not like the word "inventing." We are sorry, but can use no other word, because any new idea in engineering is a product of the inventive imagination.

• •

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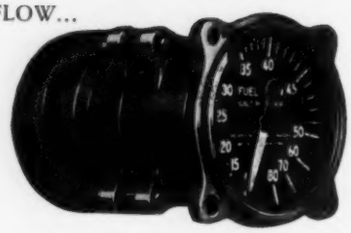

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isms and the requisite auxiliary power which otherwise would have to be provided for in the transmitting sections. Thus, the *final* elements of such already-installed relay-type recorders become the *primary* elements of the telemetering systems.

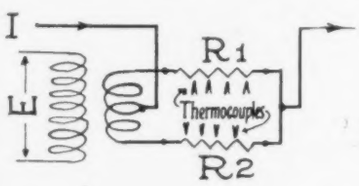
Figs. 44-14 and -15 show the application of a Leeds & Northrup voltage-class transmitter to an already installed Westinghouse relay recorder.[7] A voltage-dividing rheostat of the potentiometer type, driven by means of a sprocket wheel directly from the lead screw of the recorder, applies to the interconnecting line a potential difference (derived from a battery of dry cells or from a rectifier) proportional to the reading of the recorder. At the receiving end of the line there usually is a Leeds & Northrup recording potentiometer[8] graduated in units corresponding to those of the recorder which commands the transmitter. (In some load-dispatching stations the receiver is a "giant pointer" form of potentiometer indicator installed in a conspicuous place.)

The voltage-balancing system of telemetering may readily be adapted to the transmission of any magnitude whose variations may be made to govern the adjustment of the transmitting rheostat; and the method is capable of a wide range of modification in the nature of totalizing, re-transmission and remote control.

Since the receiver of a voltage-balancing system is a self-balancing potentiometer and since such an instrument likewise is of the relay type, it may be used for retransmitting in either of two ways: (1) by mechanical connection to a transmitter similar to that at the initial station or (2) by being provided with a second circuit. Such two-circuit combination receiving-and-retransmitting potentiometer recorders find important applications in modern power distribution systems.

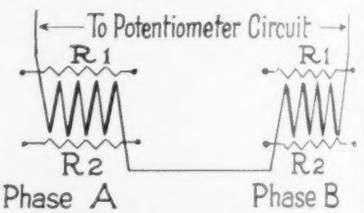
(c) The Thermal System

An outstanding modern system of telemetering, coming within the voltage classification and particularly suited to the measurement and totalization of electrical power loads over moderate distances, is based on the use of the Lincoln thermal converter. This device combines the circuit of the thermal wattmeter[9] with a series of thermocouples, producing an electromotive force directly proportional to the power under measurement, thus making possible the totalizing of a number of individual blocks of power, or the measurement of their algebraic sum, at a central point. While capable of high precision and of great flexibility, this method is limited by the relatively low value of voltage developed, and its application is generally confined to the totalization of urban power loads, where the cost of an enclosed circuit is not prohibitive.



Elementary circuit of the Thermal Wattmeter in relation to Thermocouples.

Fig. 44-16



Thermocouple circuit in relation to Heaters.

Fig. 44-17

For detailed descriptions of this system, as originally developed in 1925-26 for totalizing a 150,000-kw load, and of subsequent installations, refer to the bibliography.[10]

The essential principle of the thermal converter will be understood by reference to Figs. 44-16 and -17, which show the thermal wattmeter circuit and

[7] See *Instruments*, Jan. 1935, pages 11-13.
[8] See *Instruments*, Feb. 1935, pages 35-37.
[9] See *Instruments*, June 1935, page 151.
[10] Fawsett. *Electrician* (London), Vol. 88, Jan. 20, 1922, page 71.
P. A. Borden. Totalizing the Load of Four Stations. *Electrical News* (Toronto) Vol. 35, Dec. 1, 1926, pages 35-38.
P. M. Lincoln. Totalizing of Electric System Loads. *Trans. A.I.E.E.*, Vol. 48, 1929, pages 773-782.
37,500-kva Diesel Plant at Vernon, Calif. *Electrical World*, Nov. 4, 1933, page 590.
F. Zogbaum. Load Totalizing in the New York Area. *Electrical Engineering*, Vol. 53, June 1934, pages 886-889.
W. T. Lank. Interconnection Economies through Telemeter Totalizing. *Electrical World*, June 30, 1934, pages 948-949.
U. S. Patent No. 1,765,563. Borden, Baker & Paine, June 24, 1930.

the thermoelectric circuit respectively. As explained in the discussion of the thermal wattmeter,[9] resistances R_1 and R_2 tend to assume a temperature difference proportional to the watts in the circuit; and it is obvious that a series of thermocouples having their "hot" and "cold" junctions associated with the respective resistors, as indicated in Fig. 44-17, will develop an electromotive force representative of the temperature difference, and hence of the power load in the a-c. circuits of the instrument. A complete thermal converter, with its cover removed, is shown in Fig. 44-18. It incorporates a pair of these circuits, together with compensating devices to give a linear characteristic be-

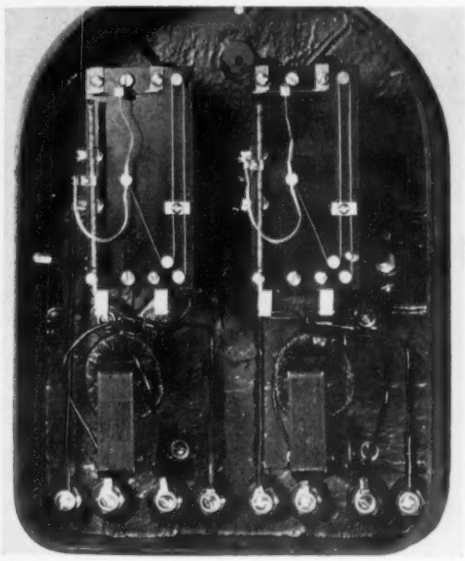


Fig. 44-18

tween the power and the millivoltage generated, and adjustments to provide the correct ratio between the two. It usually is designed to develop a terminal emf of 20 millivolts with a load of 500 watts in each of its two elements. The method of design has reduced the time lag to about 10 seconds. The a-c. terminals are connected, identically with wattmeters, in the secondary circuits of instrument transformers; and, as the converters contain no moving parts and require no attention, they may be placed in practically any location, usually on the rear of a switchboard panel. The d-c. terminals of a group of converters are connected in series for totalization; and, as a reversal of power flow in a feeder reverses the output millivoltage of the corresponding converter, the total power is at all times represented by the algebraic sum of the emf's in the d-c. circuit.

The receiver takes the form of a recording potentiometer; and subtotals may at any time be taken with another recorder or a portable test set without interfering with the main record. While the thermal converter is inherently applicable to the voltage system of telemetering, it has also been applied in a form where the emf developed in the converter is opposed by the drop across a shunt carrying an automatically adjusted direct current, this current being transmitted through the line to a receiving instrument of the milliammeter type. This modification makes possible the joint totalizing of loads measured by the thermal system and by the current system described in the preceding section. The Lincoln thermal system of telemetering and totalizing is at present supplied in the United States by the Leeds & Northrup Co. and in Canada by the Sangamo Electric Co.

(d) Induction-torque Balance System

In the induction-torque balance system of Trub-Tauber (Switzerland), Fig. 44-19, the transmitting unit takes the form of a small induction regulator, having a primary winding energized from an a-c. source, and delivering to the line a voltage whose value depends upon the position of the movable secondary winding, as governed by the primary measuring element. The receiving unit, generally similar in structure to the transmitting unit, has its primary winding energized from the same a-c. source as the transmitter, and its secondary con-

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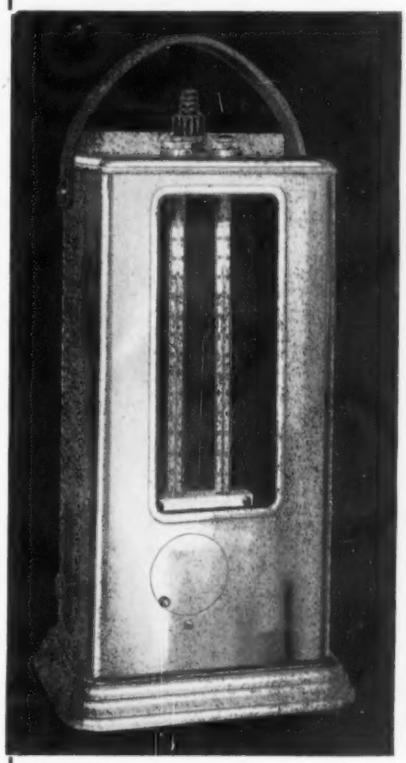

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nected to the transmitting line. If the secondary coils do not occupy corresponding positions in regard to their primaries, there will exist an unbalance of emf, which will cause a current to flow in the line, and the reaction of this current on the primary flux will tend to shift the moving secondary in the receiving unit to a position where its voltage becomes equal and opposite to that set up in the transmitter. Thus the receiving instrument tends to duplicate the position of the transmitting unit. As this method is based on the balancing of voltages, the reading of the receiver is independent of the resistance of the transmitting line so long as sufficient current flows to restore the moving coil to its balance position. Since it is necessary, however, that both units be excited from identical a-c. potentials, there must be provided in addition to the transmitting line such electrical circuits as will supply the essential excitation.

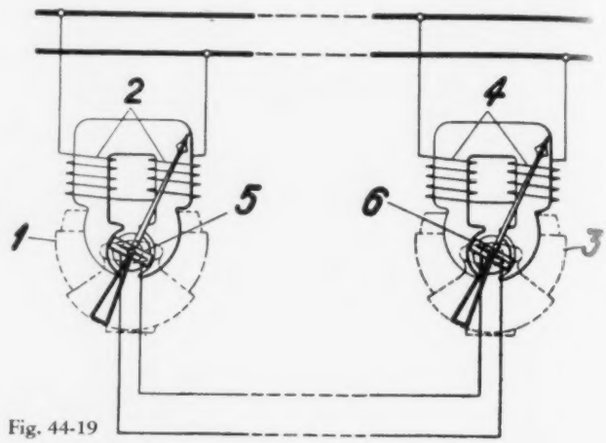

Fig. 44-19

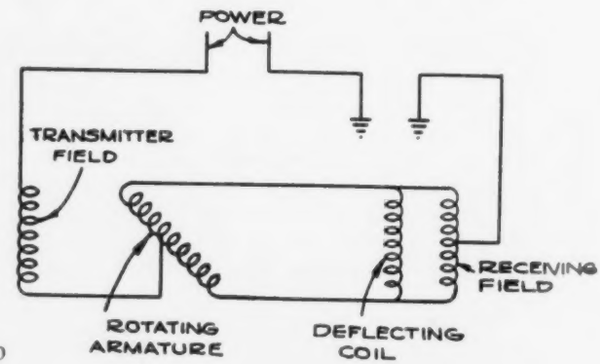

Fig. 44-20

An American modification of the induction-torque balance system is that of Wallace & Tiernan Products, Inc., Fig. 44-20. The transmitter embodies the same essential principle of a direct-actuated regulator, varying its output voltage with the position of the primary measuring element. The receiving unit takes the form of a direct-deflecting instrument having a stationary electromagnet excited from the transmitted current and acting upon an iron vane, which is deflected in proportion to the voltage applied to the magnet winding.

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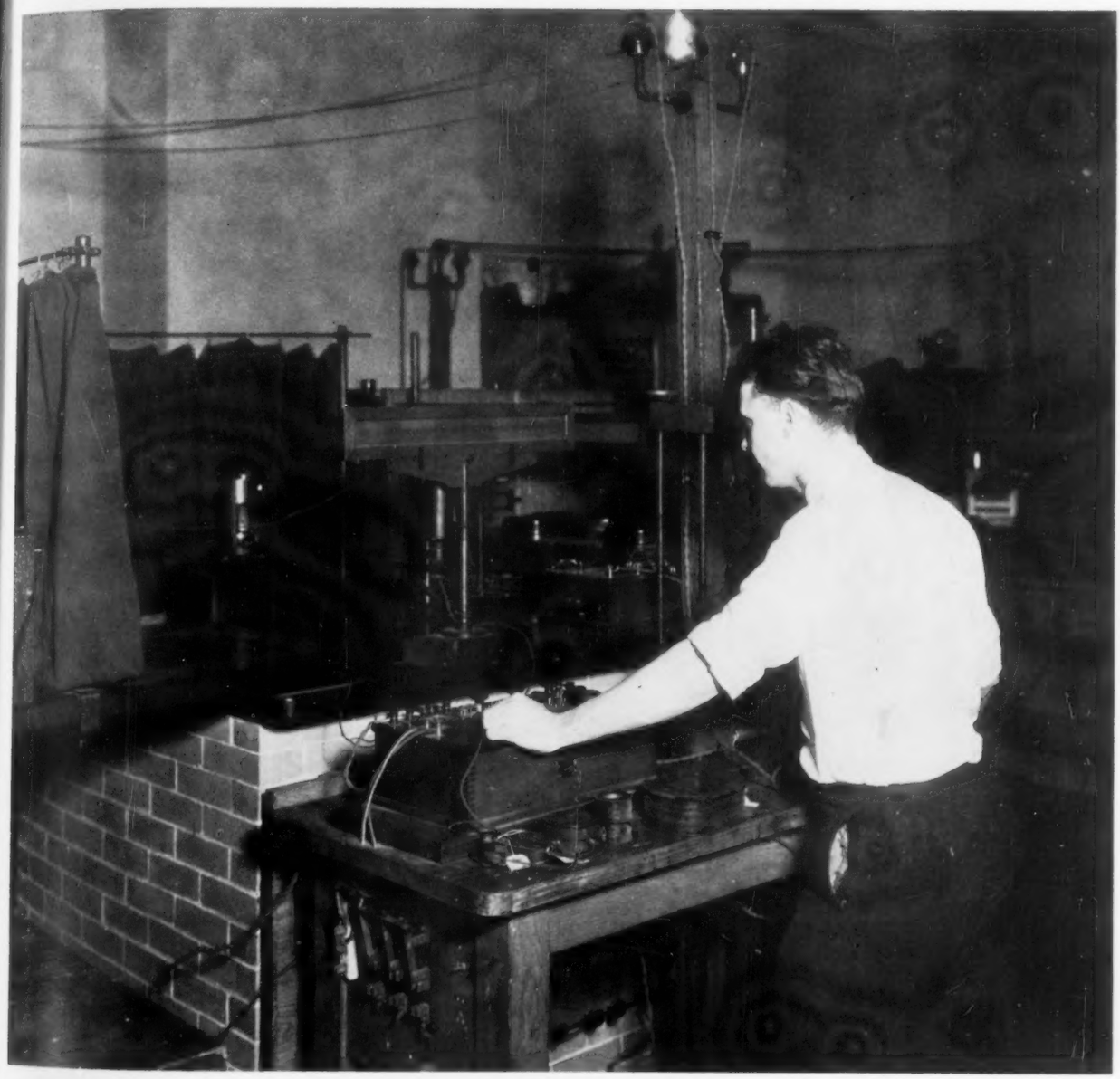


COUNTING COIL-TURNS ELECTRICALLY

(Courtesy General Electric Co.)

Vacuum Gaging in Lamp Manufac ure

By L. D. LOCKWOOD
Engineer, Westinghouse Lamp Company, Bloomfield, N. J.

MACHINES for assembling Mazda incandescent lamps into the finished product operate at speeds which necessitate quick and accurate vacuum readings. In one instance, a lamp is evacuated from atmospheric pressure to 250 microns in 15 seconds. Later on the same lamp may be "flushed" several times with 100,000 microns of nitrogen gas and evacuated to 50 microns, allowing between 12 to 15 seconds for the operation. Ultimately, almost all traces of air are replaced by nitrogen which, being inert, does not impair the subsequent performance of the lamp. Without accurate vacuum control, however, lamps with too much air in them might pass all the inspection checks, get into the hands of consumers and, by their certain short life, destroy good-will towards the product.

In developing pumps for this exhaust work, it was absolutely necessary to have gages that would measure these conditions accurately and rapidly. The McLeod gage, formerly used, was unsatisfactory because it read only one pressure at a time and required at least 30 seconds to take it. The micron gage now used is designed on the principle of the original Pirani gage, but possesses modifications which insure continuous operation over long periods and which increase the speed of indicating the pressure changes. Its primary measuring element is the Westinghouse WL 762 electronic tube which operates on the principle that the temperature (and hence the resistance) of a filament through which a current is flowing varies with the kind and amount of gas present to dissipate the heat. Its resistance measuring circuit is an unbalanced Wheatstone bridge whose galvanometer is graduated in microns—the WL 762 having been calibrated according to the characteristics of the gas to be evacuated.

PLATINUM RIBBON FILAMENT

For use in lamp manufacture there was required a Pirani gage that would respond *quickly* to pressure changes. The cooling effect on the filament had to be maximum, requiring a filament of small cross section. A thin ribbon form was finally adopted, because its large ratio of surface to volume afforded maximum sensitivity to pressure changes. After careful consideration, platinum was selected as the filament material. Although it does not possess the highest temperature coefficient of resistance, it meets all other requirements more satisfactory than other metals. With an impure filament material, the coefficient drops fast, especially when an oxide forms, whereas platinum resists oxidation under the conditions met in lamp manufacture—often a dull red heat in air. Other advantages are that it can be rolled thin enough to give the required surface contact and still remain soft enough to handle in mounting procedure, and can be annealed easily (which is necessary after cold working).

All strands of the ribbon filament are parallel but do not touch. The design of the filament is such that the tube must be operated in a vertical position to obtain most accurate readings which are required in certain checking operations.

To minimize the cooling effect of room currents and to minimize the effect of light on pressure readings, especially where extremely low vacua are measured, the bulb of the measuring tube is made as small as possible and is constructed of heavy glass. Barometric pressure and temperature changes in the room are counteracted by the use of a reference tube in the other parallel of the Wheatstone bridge: this tube is kept always open to room pressure and its filament temperature held as closely as possible to that of the measuring tube.

Though the gages for factory use are calibrated in microns, the readings are only approximate because different gases affect the cooling rate of the filament. When a good reading is obtained, the vacuum is no worse than indicated because water vapor, mercury vapor and all heavy gases cool faster than dry air. When McLeod

Fig. 1. Using a hot-wire gage to obtain a continuous indication of the degree of vacuum while exhausting Type G-5 ultraviolet lamps in the Westinghouse Lamp Co.'s plant. Arrow shows the Pirani tube, attached to the end of the vacuum manifold.

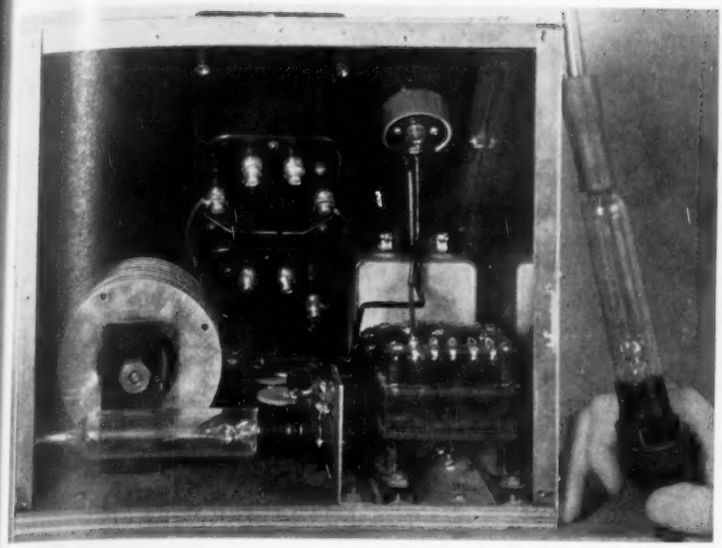


Fig. 2. Interior view of the cabinet of one of the Pirani gages used at the Westinghouse Lamp Co.'s plant, showing transformer, Rectox, and reference tube which is always left open to room pressure to compensate for barometric pressure and temperature changes in the room. The tube held at the side is shown as it is used to check vacuum conditions on the lamp assembly machines.

gages were used for vacuum readings, any gas that would condense under pressure would not indicate. Hence, when a reading appeared favorable, the conditions were often considerably worse.

CONSTANT POWER SUPPLY ESSENTIAL

The final problem confronted in the use of this Pirani gage was that of power supply. Either a constant d-c. voltage or a constant d-c. current across the bridge was essential to dependable readings and constant calibration. At first, a storage battery seemed the simplest method of obtaining power, but unstable voltage supply obviously made it impractical.

For general factory operation, best results are now obtained with constant voltage, produced by a-c. current and transformer, changed to d.c. by a Westinghouse Rectox. The resistance of the Rectox increases gradually, and adjustment is made easily by increasing the a-c. voltage when periodic checks show this to be necessary.

A constant-current Pirani gage, which is slightly more accurate than the constant-voltage type but which is also more costly to operate, is used to check gages and for processes which require more accurate results.

USE THREE TYPES

Three types of hot-wire micron gages are now used in the various phases of lamp manufacture. First is a portable type, for checking exhaust pumps and machinery (commonly known as the sealing and exhaust machines) upon which Mazda lamps are assembled. These gages read accurately to 0.25 micron. One of them gives a permanent and complete chart record on exhaust equipment for any check period; it need not be watched during operation.

A second type is used as a leak detector on individual assembly machines. No indicating dial or recording chart is necessary as this type of gage operates a relay which closes the vacuum port and preserves the vacuum draw for the other lamps on the machine. The unevacuated lamp is removed later by the operator who, having been notified previously by a flashing red light, detects its condition by high-frequency methods.

The third type provides the final check on lamps just before they are tipped (sealed and made air tight). If the pumps, the connecting lines, or the lamp show a leak, it is detected by this gage and the sealing procedure stopped automatically while the condition is rectified. Likewise having no indicator, this gage operates a relay which flashes a red light and, in some instances, closes the port and rejects the lamp automatically. It provides a sure check on exhaust conditions because the lamps are rejected when the pressure rises to 80 microns —although a good lamp can be made with pressures several times greater. The degree of vacuum varies between 20 and 80 microns depending upon the type of lamp manufactured.

The employment of gages which give continuous, instantaneous readings of vacuum disclosed real sources of trouble in pumping systems. In some cases the connecting lines were too long or too small in diameter. In other cases it was either leaks or dirt in the lines and connections.

The Merit Factor Question

To the Editor:

With regard to F. S. Stickney's article "The Factor of Merit for Horizontal-shaft Electrical Indicating Instruments" in the May, 1935 *Instruments*, there is one small point on which I should like to comment. On page 114 it is stated that I have "shown that the coefficient of friction of sapphires may vary considerably depending upon the orientation of the crystal structure with respect to the size of the cavity. Measured frictional variations of the order of 2.2 to 1 were reported due to this cause."

In the experiments on which this statement is evidently based*, eight sapphire jewels were subjected to wear tests. The initial frictional torque before beginning the wear test was measured for each jewel and the highest value obtained was 2.2 dyne-cm. and the lowest 1.0 dyne-cm. Excluding the highest value, however, the initial frictional torque of each of the remaining seven jewels was within ± 0.2 dyne-cm. of the mean value 1.2 dyne-cm. for these seven jewels. The variation in *initial* friction was therefore, on the whole, not very marked.

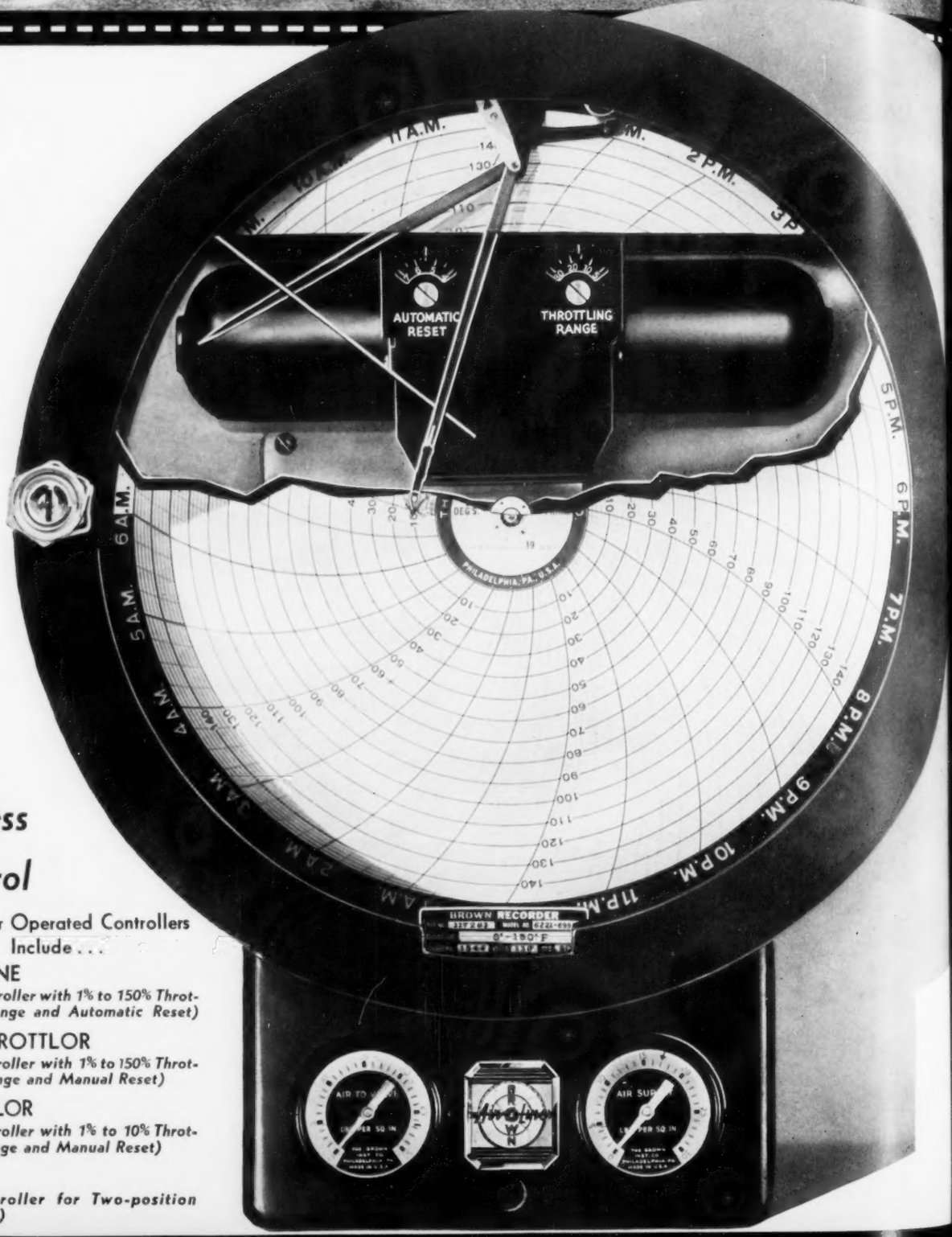
The increase in *friction due to wear* under identical conditions, however, was markedly different with jewels of *different orientation* and the fact that a jewel when new exhibits small friction is no guarantee that it will exhibit small increase in friction due to wear.

VERNEY STOTT

The National Physical Laboratory
Teddington, Middlesex (England)
July 31, 1935.

*Table XIII of "An Investigation of Problems relating to the use of Pivots and Jewels in Instruments and Meters." *National Physical Laboratory Collected Researches*, Vol. 24, 1931.

Forward Strides



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Electrode Arrangements for Cathode ray Tubes

Fourth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in the July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

ELECTRON GUN ARRANGEMENTS[1, 2, 3, 4, 5, 6]

In cathode-ray tube design, the shape and location of the electrodes affect several different factors in the control of the ray, so that it is difficult to segregate the various items and to describe their operation separately. Therefore, in describing the electron jet generating electrodes, the focusing and modulating arrangements may be involved as well, although it is intended that electrodes particularly designed for focusing be discussed separately in the next article.

In any type of cathode-ray tube, the source of electrons is the cathode, which is usually heated. Due to the location of the anode, with its high positive potential, the stream of electrons is directed along the axis of the tube. All other electrodes function to concentrate, focus, modulate and deflect the jet.

In most tubes the anode consists of a disk with a small central hole, or of a tube with a small bore, or of a combination of both, in order that all cathode radiation be shut off except the small stream permitted to pass through its central orifice. The anode (carrying the positive potential) and the filtering diaphragm (which shuts off all but the useful radiation) may be separate elements, maintained at different potentials. However, in this discussion the anode will be considered as accomplishing both functions.

In early tubes the cathode was not heated and a high anode potential (say 10 kv. or over) was required to initiate the ray. As cathode design improved, it was seen that there was no advantage in using cold cathodes, and the hot cathode principle is used almost exclusively, even in high-voltage tubes.

HOT CATHODE DESIGNS

Wehnelt discovered while investigating cathode rays that a heated filament coated with lime or other alkaline earths gave out an abundance of electrons. Subsequently practically all types of electron tubes have made use of this discovery. For use in a cathode ray tube several items must be considered in the preparation of the cathode. The amount of light emitted must be small, to prevent illuminating the screen by direct or reflected light. Usually a heavy oxide coating is provided in tubes that are not highly evacuated, since the oxides are readily reduced by the bombarding action of gas ionization.

Since a point source of rays is ordinarily required to simplify focusing, a short filament drawing a heavy current is generally used. Fig. 1a shows a simple flat platinum ribbon type filament which has a spot of "lime" on its surface at the center. Such an arrangement is one of the earliest used in the hot cathode type of tubes.

Fig. 1b represents the loop filament used in a well-known Western Electric tube (Type 224A illustrated also in Fig. 3).

Fig. 1c represents the double loop type of filament used in the Von Ardenne tube, which is attributed to Van Hartel. It may be seen also in the photograph (Fig. 4 of the July article) which brings out details of electrodes and deflecting elements. The main feature of this structure is that the filament and its supporting leads are twisted into a double loop, so that the magnetic field produced by one section opposes that of the other. Since the loop that includes the filament support leads is farther away from the cathode stream than is the filament loop, it is designed to include a larger area. The filaments usually carry several amperes of current and the field might normally produce false deflections.

Fig. 1d represents the type used by DuMont. A short projection welded to the filament is tipped with the active material "O."

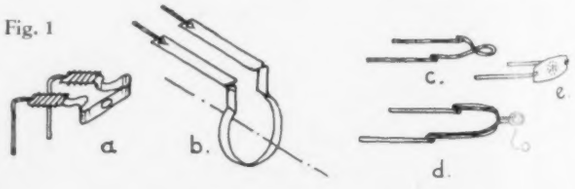
Another type of filament, Fig. 1e, found in some German tubes, is similar to that shown in Fig. 1a, but has a well-defined concave depression at the center, which alone is covered with the active coating. The feature of both types is that the smallness of the active area of the emitting surface contributes to the ease of focusing the stream. In addition, the effect of the concave portion is to produce a focus point between the cathode and anode, which is easily discerned when the tube is correctly operated. The filament leads in the latter arrangement are kept close together to reduce the magnetic field when the filament is heated with alternating current.

The active material used for the filament coating may be similar to that used in dull emitter vacuum tubes, and generally is a single or a combination of rare earth oxides. A copious stream should be obtained at relatively low temperatures to reduce the amount of visual illumination in the tube.

While the magnetic field associated with a short straight filament may have considerable strength near the surface, its influence rapidly decreases as the electron moves away. Nevertheless, when alternating current is used to heat the filament, the effective center of emission may waver back and forth due to this field, and distortion may be experienced in the oscillogram.

This field produces additional forces on the jet beside the normal force (toward the anode) and causes some of the electrons to follow a curved path essentially parallel to the filament. That is: an electron leaving the filament near one end follows a curve and if the filament were long enough and the current strong enough the electron would curve around and hit the filament again farther along toward the positive end. This effect is present in all types of electronic tubes, and is usually termed the Magnetron effect. The shortness of the fila-

Fig. 1



[1]Johnson. The Cathode Ray Oscillograph. *Journal of the Optical Society of America*, Vol. 11, 1932, pages 1-27.
[2]Wood. The Cathode Ray Oscillograph. *Journal of the Institute of Electrical Engineers* (London), Vol. 63, 1925, pages 1046-1056.
[3]MacGregor, Morris and Mines. Measurements with the Cathode Ray Oscillograph. *Journal of the Institute of Electrical Engineers* (London), Vol. 63, 1925, pages 1056-1096.
[4]Kolster. A Direct Reading Decremeter and Wave meter. *Proceedings of the Institute of Radio Engineers*, Vol. 3, 1915, pages 29-54.
[5]Steenbeck. Cathode Ray Tube Development History. *Archiv Fuer Technisches Messen*, Vol. J 834, Sec. T 76, 1931.
[6]Johnson. A Low Voltage Cathode Ray Tube. *Journal of the Optical Society of America*, Vol. 1, 1922, pages 142-151.

ment in a cathode-ray tube minimizes this effect, but the dispersion does affect the fineness of the focus, and causes the spot to oscillate at the power frequency rate.

The usual effect of this field is to transform the spot into a short line. The direction of this line on the screen usually bears no particular relation to the axis as determined by the deflection plates. If, however, this "line" is deflected by other means, it moves as a fine wavy line. Various effects are possible, depending upon the frequencies of the measured wave and of the supply voltage.

In case this distortion is found, it may be improved in some cases by an external coil mounted alongside the tube near the cathode, containing three or four turns of heavy wire, and connected in series with the filament. The exact location must be found by experiment, and will generally change if the filament current is varied.

If this arrangement is ineffective with any type of tube, the only other expedient is to use direct current to heat the filament. In one instance a rectified alternating current proved satisfactory, a heavy-duty copper oxide rectifier being employed.

MISCELLANEOUS DESIGNS

Many designs for cathode-ray tubes have been recorded by investigators. A considerable proportion of these have been developed for special scientific investigations, such as the study of electron movements, the measurement of e/m, and other problems. Since many of these commercial and non commercial designs are adapted for other uses as well, descriptions of a few of the most interesting follow. The details will embrace the construction of the generating end of the tube only, the so-called "electron gun." For complete details and results of these and other designs, the original articles cited, and others listed in the bibliography, should be referred to.

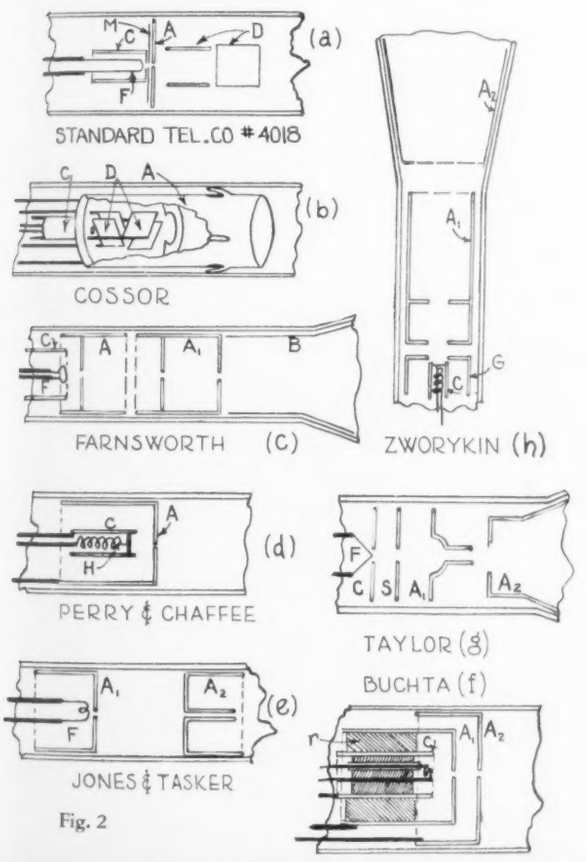


Fig. 2

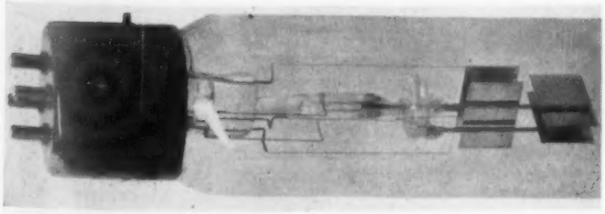


Fig. 3

A tube designed for the study of magnetic fields has been disclosed by Bruche.[7,8] A hot cathode, having a very small active area, was placed very close to the anode which operated at a low potential, *i.e.*, 50 volts or less. The anode was of funnel shape with the large end nearest the cathode. A pressure of 0.001 mm. of mercury vapor was used. The feature of this tube is its extreme sensitivity due to the low anode potential required.

Several designs disclosed by Selenyi[9,10,11] have anodes formed by a metallic coating deposited on the inner wall of the tube, connected to a suitable terminal. In some arrangements the deflection plates were of this form, too. The attendant difficulties of securing a satisfactory contact with these coatings, the non-uniform field and the lower sensitivity due to spacing, would seem to make this scheme less practical than standard forms.

Rogowski has disclosed several cathode-ray tube designs,[12,13] usually employing high anode potentials. In one type the cathode is formed by a molten pool of the active oxide, giving an extremely intense bundle of rays.

A recent commercial design of tube has an electrode arrangement as in Fig. 2a. The Wehnelt cylinder extends close to the anode, but is insulated therefrom by a small mica disk (M) with a central opening. The correct focus is obtained, independently of filament temperature, with a positive bias applied to this cylinder, depending upon the anode potential used. For example with an anode potential of 550 volts approximately 40 volts are applied to the cylinder. This tube is produced by the Standard Telephone Co. of London.[14]

Among other recent commercial designs, the Cossor tube deserves particular mention. It is a gas focused tube with internal deflection plates, as indicated in Fig. 2b. The unusual feature here is the shape of the anode, which extends beyond and substantially shields the deflection plates, except for the large orifice at the outer end, which permits the passage of the deflected ray. This arrangement represents a definite attempt to cope with the stray electron current. The cathode-ray beam carries a certain amount of energy which cannot accumulate indefinitely on the screen or elsewhere. This energy must leak off and return through devious paths to the anode circuit. Conduction currents along the glass, ionization of the gas, the secondary radiation from the screen, all tend to disperse this charge, but the deflection plates collect a large proportion of it, being in the most exposed position. As will be seen in Fig. 2b, the

[7]Bruche and Ende. Fadenformige, sichtbare Electronstrahlen, magnetic demonstrations. *Zeitschrift fuer Physik*, Vol. 64, 1930, pages 186-190.

[8]Bruche. Biegsame Electronenstrahlen. *Zeitschrift fuer Physik*, Vol. 78, 1932, pages 177-195.

[9]Selenyi. Uber die Verwendung der Negativen Ladung. *Zeitschrift fuer Physik*, Vol. 47, 1928, pages 895-897.

[10]Selenyi. Uber die durch Kathodenstrahlen bewirkte elektrische Aufladung des Glases. *Zeitschrift fuer Technical Physik*, Vol. 9, 1928, pages 451-454.

[11]Selenyi. Cathode Ray Tube. U.S. Patent No. 1,818,760.

[12]Rogowski and Baumgart. Ein Gluhkathoden Oszillographen fuer Vakuumaufnahmen. *Archiv fuer Elektrotechnik*, Vol. 19, 1928, pages 521-526.

[13]Rogowski. Flegler and Buss. Die Leistungsgrenze des Kathodenoszillographie. *Archiv fuer Elektrotechnik*, Vol. 24, 1930, pages 563-566.

[14]MacGregor, Morris and Wright. Accuracy of Measurements with Gas Filled Cathode Ray Tubes. *Journal of the Institute of Electrical Engineers* (London), Vol. 71, 1932, pages 57-82.

anode (A) shields the deflection plates (D) and a more stable operation is assured. The cylinder (C) is utilized for focusing.

A recent tube development at the DuMont Laboratories is provided with a heavy long-life filament capable of producing heavy emission. A Wehnelt cylinder is utilized for focusing, utilizing the gas ionization as a contributing factor.

An example of an arrangement with a multiple "anode" is afforded by a recent Westinghouse tube. In this tube the inside of the conical portion of the bulb is coated with a conductive material to form the main anode. The electrostatic capacity between this coating (particularly its inner edge) and the focusing electrode (sometimes referred to as an anode) forms a field which acts to reconcentrate the normal dispersion of the ray as it progresses toward the screen. It is necessary that the characteristics of this field be carefully controlled, and this is done by adjusting the potential between the anode and the focusing electrode. The latter element usually requires a potential about 20% of that applied to the coating on the glass. While it is not essential that the anode coating extend clear up to the screen, as far as the focusing action is concerned, yet this provides an excellent collector for the stray electrons.

The focusing action is largely independent of gas pressure so that such tubes are exhausted to a higher degree, which eliminates the detrimental effects due to gas ionization. More details of the focus principles are taken up in a later article.

In the Westinghouse tube just referred to and in a similar way in the RCA tubes and others, additional control electrodes are provided between the first anode and the cathode, as indicated in the sketch Fig. 2h. The control (G) is located near the cathode, and with usual connections does not affect the focus, but—in a manner similar to the control grid in other electron tubes—influences the electron current density and hence the intensity of the ray. The control adjustment provided in oscillographic equipment to vary this effect is therefore usually designated as "brilliance control."

The curve, Fig. 4, is reproduced from data supplied with the RCA Type 905 tube, Fig. 5, and is representative of the conditions found in other tubes of this same general design. This modulation grid will prove of value in certain tests, and also in the modulation of ray for use in television.

In these tubes the deflection coils are usually located near the inner edge of the anode coating. Rough measurements made by the author on the tube shown in Fig. 8 of the preceding article show that the ray is accelerated quite rapidly after emerging from the first anode and that the effective velocity at the point of deflection is probably the same as the final value.

Among the early applications of the multiple anode focus system, a design by Jones and Tasker[15] utilizes double anodes as is indicated in Fig. 2e. The anode nearest the cathode is used as a focus control. A definite positive voltage relation must be applied to both electrodes, depending upon the interspacing. A gas pressure of 0.002 mm. of mercury was used. In one type the spacing (F) to (A_1) was 0.5 mm., with a 2 cm. spacing between the anodes (A_1) and (A_2).

An unusual arrangement was disclosed by Chaffee, wherein a circular ring was used as the anode. Since the orifice was relatively large, focusing was accomplished by the use of a large concentric magnetic field and by the use of a "point" source of electrons, obtained by limiting the active area of the filament. The effect produced by concentric magnetic coils will be taken up later.

In a television tube disclosed by Von Ardenne, two anodes were used to which 800 volts and 300 volts were respectively applied. A coaxial cylinder located between these anodes had the effect of concentrating the beam and producing a sharper focus. This arrangement is shown in Fig. 6.

Fig. 2f represents a design due to Buchta[16] who has disclosed a type of electronic gun distinguished by the low anode potential, making the tube ultra-sensitive to deflecting fields. A relatively large amount of gas is used in the tube (mercury vapor, the pressure of which corresponds to room temperature). The anode has two orifices (A_1) and (A_2) and the focus cylinder (C) is connected to the filament.

[15]Jones and Tasker. A New Cathode Ray Tube. *Journal of the Optical Society of America*, Vol. 9, 1923, pages 471-480.

[16]Buchta. A Low-Voltage Oscillograph. *Journal of the Optical Society of America*, Vol. 10, 1925, pages 581-590.

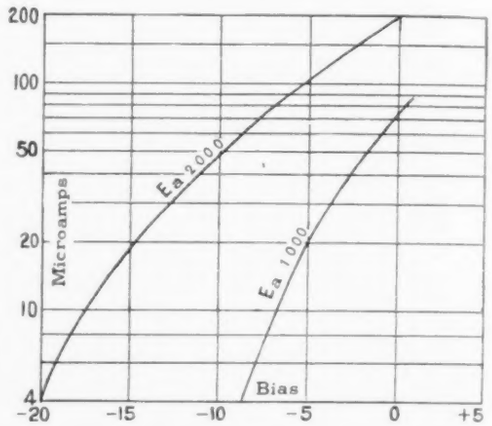


Fig. 4

Fig. 5

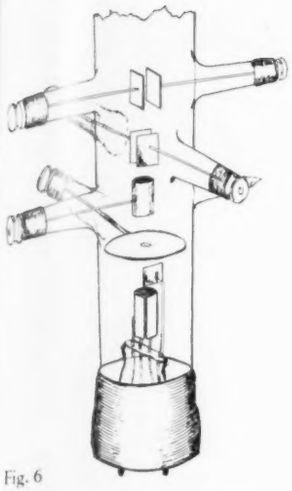


Fig. 6

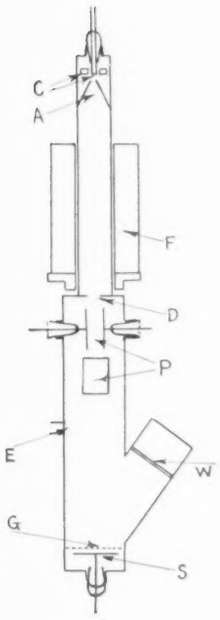


Fig. 7. A—anode. C—cathode. D—diaphragm. E—to exhaust. F. Focus coil. G—grid. P—def. plates. S—screen. W—window.

Another tube, developed by Chaffee and Perry for the study of electron velocities and the measurement of e/m, is shown in Fig. 2c. This tube has a unipotential,[17] indirectly heated cathode in the form of a deep cup (C) the end of which is coated with oxides, and containing a heater (H). The anode (A) is coaxial.

H. E. Farnsworth has disclosed[18,19] several tubes, one of which has an arrangement similar to that illustrated in Fig. 2c. An oxide-coated platinum filament is used, carrying about three amps. Two (or three) anodes are provided: carbonized to reduce the secondary emission.

As improvements in the design of cathode ray tubes are made, the problem of the simultaneous recording of two or more waves by the use of multi-jet tubes is receiving more attention. Dufour[20] has shown a tube which can be converted to a double-jet tube at will. The tube is a Y-shaped arrangement with electron generating electrodes, and deflection plates in each of the upper arms. The two rays are bent by two small electromagnets located near the junction point to permit the two rays to pass through the stem to the recording system.

Other double-jet tubes have been recently designed by Boekels and Dick[21] and by Winckle.[22]

A number of designs have been disclosed wherein the cathode ray is given a high acceleration just before striking the screen. The deflection system therefore operates on low velocity rays and increased sensitivity is possible. A representative example of this method of two stage acceleration is a tube, Fig. 7, described by Harris,[23] built by the Bureau of Standards. While this is not the first arrangement that has been disclosed utilizing this principle, it furnishes an excellent example of what can be done. Quoting the above paper:

The cathode is an oxide coated filament surrounded by a metal shield which is held at the same potential as the filament. This shield has a plane surface facing the anode and the small hole in its center is almost completely filled by the filament. The cathode system thus is practically a plane surface having a central hot spot which serves as a source of electrons.

The anode is a cone, pointed toward the cathode, with a small hole at its apex through which the electron ray passes. As a result of the focusing action arising from this point-plane arrangement, an intense beam of electrons passes through the hole in the anode and down the tube.

The electron beam is brought to a focus at the fluorescent screen by means of a coil located midway between the anode and screen. After going through the field of the focusing coil, the beam passes through a diaphragm, between the deflection plates, and then through a grid before striking the fluorescent screen.

The fluorescent screen is made of finely powdered willemite and calcium tungstate deposited on a roughened aluminum plate. It is insulated from the rest of the tube which forms the body of the oscillograph in order that an accelerating potential may be applied between the grid and screen. The grid is formed of No. 40 copper wires spaced 1 mm. apart and stretched on a metal frame in electrical contact with the metal tube.

From this description it is seen that the ray is deflected after leaving the first anode, and progresses through practically the whole length of the tube before it is speeded up. The function of the grid is to prevent the high potential screen from accelerating the ray until after it passes through the grid. The first anode operates at a level of 500 volts and the final acceleration is at a 5000-volt level. The electrostatic deflection sensitivity, is about 8 volts per inch, which is several times that obtained with the average tube.

Since the screen itself is opaque it is viewed from the front.

17Perry and Chaffee. Measurement of *e/m*. *Physical Review, Series II*, Vol. 36, 1930, pages 904-918.

18Farnsworth. A Method of Obtaining Intense Beams of Slow Electrons. *Journal of the Optical Society of America*, Vol. 15, 1927, pages 290-294.

19H. E. Farnsworth. Bombardment by Slow Moving Electrons. *Physical Review, Series II*, Vol. 20, 1922, pages 358-374.

20Dufour. L'Oscillographe Cathodique, pour l'étude des basses, moyennes, et haute fréquences. (Etienne Chiron, Paris)

21Boekels and Dick. Ein Neuer Mehrfach Kathodenstrahloszillograph. *Archiv fuer Electrotechnik*, Vol. 27, 1933, pages 134-136.

22Winckle. Der Doppel Kathodenstrahl Oszillograph. *Fernsehen und Tonfilm*, Vol. 5, 1934, pages 20-21.

23Harris. Cathode Ray Oscillograph in the Study of Power Losses. *Bureau of Standards Journal of Research*, Vol. 12, 1934, pages 87-102.

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Electric Distribution Networks Improved by Instruments for Study of Lightning

By ALEXANDER SMITH
Pittsfield Works, General Electric Co.

LIGHTNING research engineers of the General Electric Co., headed by K. B. McEachron, investigate natural lightning from the only observatory in the world erected solely for the purpose of accurately viewing and recording lightning discharges. With facts gleaned during the past summer, they expect to strengthen and improve transmission and distribution equipment and thus further guard from lightning damage and consequent service interruptions the far-reaching light and power networks of the continent. Equipped with a periscope of novel design and a specially-built 12-lens motor-operated camera, the new observatory stands on top of the largest building in the Pittsfield (Mass.) works of the company. In physical appearance it is most unusual. It is built almost entirely of metal in the form of a tube 14 ft. in diameter. The exterior is painted aluminum, and the interior flat black to prevent reflections. On top is the observatory proper, completely surrounded with plate glass windows through which an unobstructed view of the entire countryside may be obtained. Within the circular room is a platform surrounded by black curtains which may be lowered at will to form a light-tight room 7 ft. square. Within this inner room is placed the periscope eyepiece.

The periscope is distinguished by the use of an 8″ crystal sphere at the peak of the structure, whose silvered surface reflects the view from all directions and sends the full-circle image down through a dark-walled tube to a mirror set at 45°. The camera placed below the structure has an unobstructed view of the entire horizon through twelve lenses and, in operation, records on a moving film all flashes of lightning within range. From these film records are obtained data on multiplicity of strokes, etc. To prevent raindrops driving against the lenses, compressed air forced through an encircling "air ring" forms a "curtain" effective against all but the most severe storms.

In conjunction with the camera, other equipment is being installed at Pittsfield and in other sections of the country—whence information already obtained is being correlated with the data gathered at the observatory.

For many years, the company's engineers have pursued special studies and investigations of lightning, both natural and artificial. Until now, however, they had not had any permanent location from which they could view natural lightning.

Commencing with the production of 1,000,000-volt artificial lightning in the famous laboratory at Pittsfield in 1923 and the application a year later of the Dufour cathode-ray oscillograph to the study of lightning, investigations by the company have gone steadily forward. Facts gathered during the past twelve years have been interpreted in the laboratory and translated into transmission and distribution equipment better able to withstand lightning voltages.

When the oscillograph was installed at the Pittsfield Works in 1924 it marked the first use in the United States of a high-speed camera arranged to record a single laboratory lightning discharge on a time-scale of microseconds, and it facilitated the study of lightning voltages. In 1926 additional equipment made possible the calibration of Lichtenberg figures to measure the amplitude of lightning impulses. In 1928, a portable artificial lightning generator, rated at 400,000 volts, was set up on the lines of the Turners Falls Power Co. and in 1930 and 1931 this equipment increased in capacity to 1,500,000 volts was operated at Croton Dam, Mich., in coöperation with the Consumers' Power Co. In 1932 the same equipment was operated at Willseyville, N. Y. Designed for operation from the ordinary 110-volt supply, it was especially valuable in field investigations.

Throughout the country, 1300 installations of surge-crest magnetic links (see *Instruments*, Oct. 1933, page 195) have been made through the courtesy of coöperating power companies and radio broadcasting stations.

With all of these major field activities have been interspersed studies of city distribution lines.

While field equipments have been operated at 1,500,000 volts, improvements in the Pittsfield laboratory have increased voltages used there to 10,000,000; and special apparatus has been constructed for production of 265,000-amp. currents.

The work continues and with the addition of the lightning observatory to the company's already elaborate facilities, network research men are better equipped than ever before to obtain information so essential to the progress of the electrical art.

NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

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Automatic Optical Pyrometer

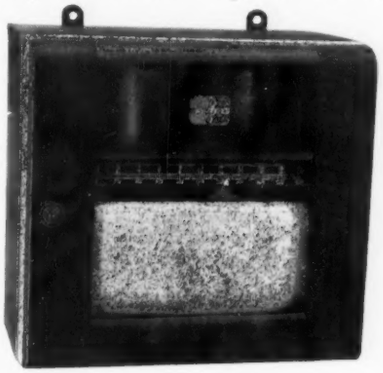
To meet at once the two needs (1) for a pyrometer adapted to measure the temperature of materials in motion about metallurgical works, glass plants, etc., and (2) for a reliable method of accurately determining high temperatures without recourse to thermocouples, the Minneapolis-Honeywell Regulator Co. announces the "Optimatic" optical pyrometer which, utilizing a narrow wave-band in the red end of the spectrum, performs automatically the work of the disappearing-filament optical pyrometer. In developing this instrument the practical needs of industry with regard to constancy of calibration, ruggedness and accuracy are said to have been placed foremost. The new pyrometer consists of

1. A water-cooled optical telescope (illustrated) which picks up monochromatic light emitted by a moving hot body or from a furnace;
2. A power supply and amplifier unit for either 25 or 60 cycle a-c. supply;
3. A standard milliampere recorder, or indicator, or both.

It is said that the Optimatic Pyrometer indicates or records the temperature of a hot body in less than half a second. The recorder and indicator are of standard makes. Critical damping has been secured and as a result the device is adapted for measuring temperatures of billets, sheets, rails, tubes, etc., while moving about the plant. Emissivity corrections for most materials being readily available and constant (for the narrow wave-band involved), actual temperatures in degrees are indicated or recorded. In the new instrument two photocells, mounted in the optical telescope, are used. One is exposed to light emitted by the surface "viewed"; the second is automatically illuminated by a standard lamp to maintain a relative value of conductivity as the first cell changes. The current in the standard lamp circuit becomes the measure of the temperature. The telescope assembly is water-cooled. (Ambient temperatures often exceed 125° F. in industrial applications.) Both photocells being maintained at the same temperature and being in opposite sides of the matching process, variations in sensitivity due to the temperature of the cells are compensated. The circuit is such that tube characteristics do not affect calibration. The device is not affected by voltage variations over a wide range.

Potentiometer Pyrometer

The Bristol Company announces the "Wide-Strip Pyrometer," available in single-record, multiple-record and recorder-controller types, all of the potentiometer class and comprising a measuring, balancing, and recording mechanism said to be "almost unbelievably simple" and to "introduce an entirely new principle of operation into temperature measurement by means of the potentiometer method": a stainless steel lead screw, operated by an electric motor commanded by two galvanometer contacts, adjusts the slide-wire contact and recording-pen unit to maintain emf balance. In this mechanism, (1) mechanical backlash is taken up, making it possible to magnify 0.001" deflections of the galvanometer pointer; (2) no clearance is required between the pointer and the



chopper arms; (3) the pen movement is proportional to the extent of the galvanometer deflection; (4) the slide wire contact and recording pen are mounted on the same carriage, which runs on four wheels over a two-rail track (3-point contact) and is driven through engagement with a hardened steel pin by a stainless steel lead screw; (5) the lead screw, mounted on permanently lubricated ball bearings, is positively driven by an induction-type motor, no friction clutches or ratchet mechanisms being used. The Wide-Strip Pyrometer derives its name from its 12¼" chart and is provided with an easily-read indicating scale (see illustration). *Other features*: The heavy-duty galvanometer is totally enclosed in a dust-proof case; the slide-wire is of the duplex type; the convertible case is moisture-, fume-, and dust-proof; the instrument as a whole is said to be easy to service in the field by the user.

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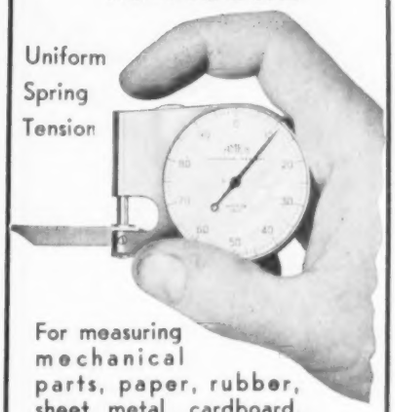

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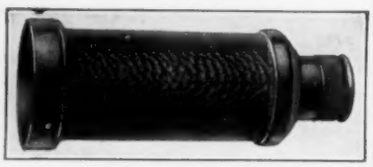

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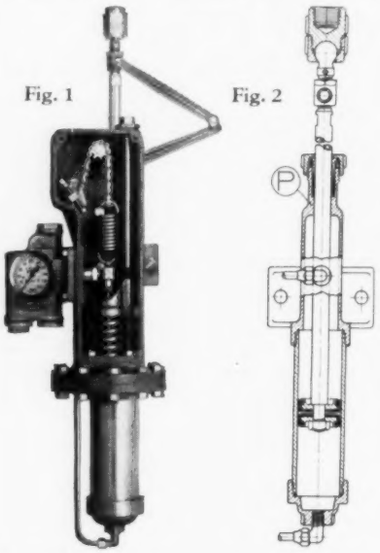


Fig. 1 Fig. 2

1—comprising (1) an actuating member—diaphragm or lever, (2) a four-way control valve which governs the flow of water, oil, or air to (3) a double-acting power cylinder which forms an integral part of the unit, (4) a built-in compensator, and (5) a simple range adjustment. The power cylinder (Fig. 2) comes in six sizes. The primary (or actuating) member may be a diaphragm responsive to the controlled pressure or differential, or a lever moved by some outside or remote means. Functions — to operate valves (balanced, chronometer, butterfly, etc.), dampers, rheostats, etc., or stokers, pulverizers, fans, and other apparatus driven by engines, turbines or electric

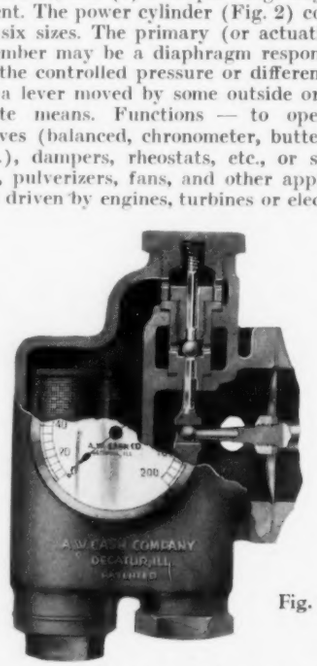
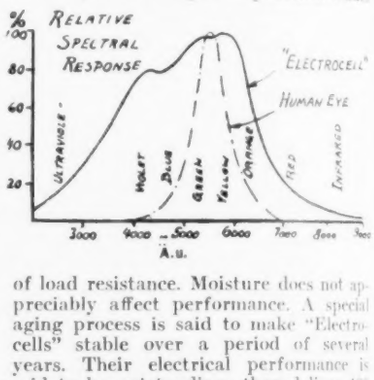


Fig. 3

motors. Among applications are automatic control of the factors affecting combustion; automatic fluid pressure reduction, regulation, or relief; back-pressure control; rate-of-flow control; liquid level control. These self-contained systems are said to be extremely sensitive because of frictionless diaphragm bearing, frictionless and leakless packing and four-way valve (Fig. 3), and the suspension of the spring load in such a manner that side strains on the vane lever are eliminated. The basic principle of the compensator is that a given percent change in the pressure under control will result in an equal percent change in the output of the apparatus under control. This principle has been worked out for all combinations of elements, assuring anti-hunting under all conditions. The entire mechanism is protected by a dust-proof cover.

Photoelectric Cells

Self-generating photoelectric elements of the dry-disk type, styled "Electrocell," are announced for American distribution by F. Loewenberg. They represent the result of a new manufacturing process aimed at achieving a cell that depends for its action solely upon the emission of electrons (photo-voltaic effect) and of eliminating entirely the undesirable secondary effect of resistance change in the sensitive surface. Time lag practically nil for all measuring and relay purposes, "Electrocells" are said to be fast enough for certain kinds of sound picture work. Temperature changes have negligible effects upon the output at practical values



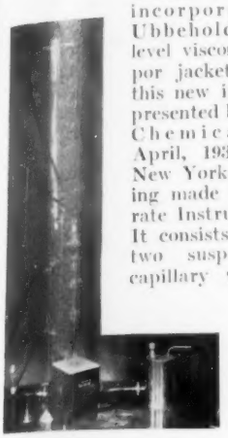
of load resistance. Moisture does not appreciably affect performance. A special aging process is said to make "Electrocells" stable over a period of several years. Their electrical performance is said to be outstanding: they deliver 480 microamps./lumen on short-circuit and 350 microamps./lumen through an external resistance of 500 ohms. In direct sunlight, maximum emf. is 0.6 volt. The 1¾" diam. cell yields up to 20 milliamps.—enough to operate mechanical relays of comparatively rugged construction without amplification. Round "Electrocell" elements range from 1" to 2⅝" diam. Rectangular shapes are also available as standard types. Special sizes and shapes can be obtained upon order.

Metallic Core Material

Use of a new material for r.f. and i.f. coil cores, in place of the conventional air-core design, is announced by Henry L. Crowley & Co. and said to increase selectivity 2¼ times, double the gain and have the power factor. Known as "Magicore" the new product consists of finely-divided particles of a Mg.-Fe. alloy, insulated and embedded in a "Crolite" ceramic binder, the material being extruded in lengths of the desired cross-sections (usually annular), cut to small lengths and fired at high temperatures. The finished "Magicores" have the appearance and feel of polished silver and are said to be uniform and permanent in mechanical properties and electromagnetic characteristics. Although produced for use by manufacturers, they are recommended for introduction into existing apparatus. A wide range of sizes is available.

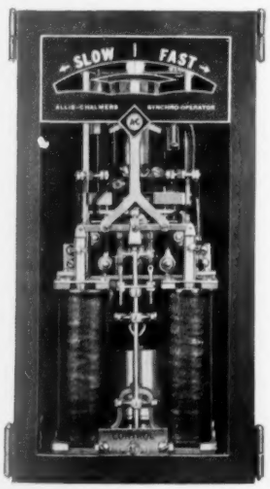
Fitz-Simons Viscometer

Said to excel other methods in accuracy, simplicity and speed, and to be especially useful where many samples must be accurately tested, the Fitz-Simons Viscometer is an incorporation of the Ubbeholde suspended level viscometer in a vapor jacket. A paper on this new instrument was presented before the Am. Chemical Soc. at its April, 1935, meeting in New York. It is now being made by The Accurate Instrument Co., Inc. It consists essentially of two suspended level capillary viscometers of different ranges, mounted in a vapor bath and so arranged that either may be instantly selected. The vapor bath does away with the need for stirrers, thermostats, etc., and is said to afford closer temperature control than attainable with thermostats. *Precision*: 0.1% with 0.02° F. temperature control and 1/5 sec. stopwatch. *Speed*: for motor oils the dual set-up (100 and 210° F.) permits one operator to run 30 to 40 oils a day at two temperatures, obtaining check result in each instance.



Synchronizing Device

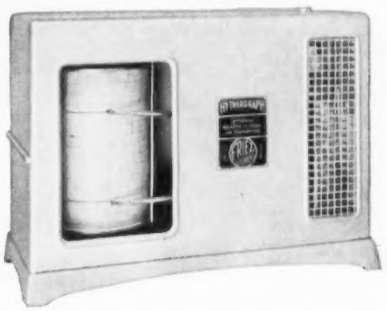
The Allis-Chalmers Mfg. Co. announces the "Synchro-Operator," an automatic control device which eliminates all human element and performs rapidly the combined functions of speed matching, synchronizing and visual phase angle indicating. It is said that these formerly required a frequency matcher, an automatic synchronizer and a synchroscope.



The "Synchro-Operator" is not much larger than the usual synchroscope and can be mounted on a swinging bracket. It accurately synchronizes generator and bus even if there is a voltage difference and it is said to be satisfactory for both stable and erratic frequencies. The control closing instant is advanced (at a phase angle proportional to the difference in frequency) to compensate for the inherent time lag in circuit breakers, thus making the breaker close at the exact point of synchronism. One "Synchro-Operator" will serve any number of generators and can be used in connection with existing governor control motors and station circuit breakers. It contains no vacuum tubes, consumes little energy, operates through standard potential transformer metering circuits and requires no special features on prime mover or generator.

Hygro-thermograph for Industrial Service

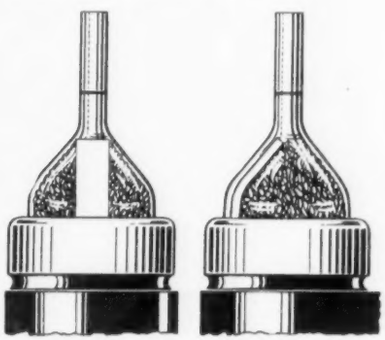
Said to be based on its makers' 59 years building of meteorological instruments, the "Friez Hythergraph," announced by Julien P. Friez & Sons, follows the general lines of that company's "Weather Bureau Hygro-Thermograph," but details have been modified, and a



commercial finish given to broaden the market. Simultaneous records of relative humidity by means of multiple human hair element, and of dry-bulb temperature by means of a bimetallic element, are given on common time lines on rectangular 24-hr. or 7-day charts, an 8-day clock being provided in either case. The instrument has been designed primarily for permanent installation in connection with air conditioning installations in buildings, or industrial work. It may optionally be supplied with a carrying handle.

Vision Panel for Orsats

To improve visibility of the solutions in the absorption chambers of Orsat gas analyzers using fibrous material for surface absorption, a vision panel has been developed by the Ellison Draft Gage Co. It is made of opal glass and is placed in the front of the chambers with a space between the panel and the chamber wall for solution passage. With the white background, close to the wall of the chamber, the solutions are visible at a distance of several feet.



Front View Side View

This Midget RESISTOR does a BIG Job Well!

Our type "R" MICROHM ½ watt Resistor shown here, actual size, is ideal for Analyzer, meter conversion and many other uses, where a compact, low-priced Resistor is required. Resistance up to 500,000 ohms. Companion to above unit is our type "S" 1 watt, which may be obtained in resistance values up to 1 Megohm. Write for samples, further information and our new catalog.

PRECISION RESISTOR CO.
334 Badger Avenue Newark, N. J.

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WIRE WOUND RESISTORS

PYRO THE SIMPLIFIED OPTICAL PYROMETER

SELF-CONTAINED, DIRECT READING RUGGED— FOOL-PROOF

Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest streams; no correction charts, no accessories.

New concentrated test mark and ease of operation permit unusually close and rapid temperature determinations.

Stock Ranges 1400° to 5500° F.

PYRO RADIATION PYROMETER

The ideal instrument for Furnace or Kiln use. Gives actual heat of material aside from furnace or kiln temperature. Does not require a skilled operator,—strictly automatic. Eliminates personal errors. Always ready to tell within three seconds any shortcomings in your equipment. Stock Ranges 1000° to 3600° F. Write for special bulletins.

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RECORDING METER

It gives trouble free service and accurate records of

FLUID FLOWS
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LIQUID LEVELS

—Extremely easy to install and can be calibrated for any differential pressure between 20 in. of water and 10 lbs. per sq. in.

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20 Microvolts to 1000 Volts

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13 RANGES
From 2 Milliamp to 1 Amp
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A Rawson Twin MULTIMETER Combines both the above in one meter

Dynamometer wattmeters, milliammeters and voltmeters. Also ultra-sensitive meters both for A.C. and D.C., electrostatic voltmeters from full scale 120 volts to over 20,000 volts, thermocouples, earth current meters, cable testers, fluxmeters, etc.

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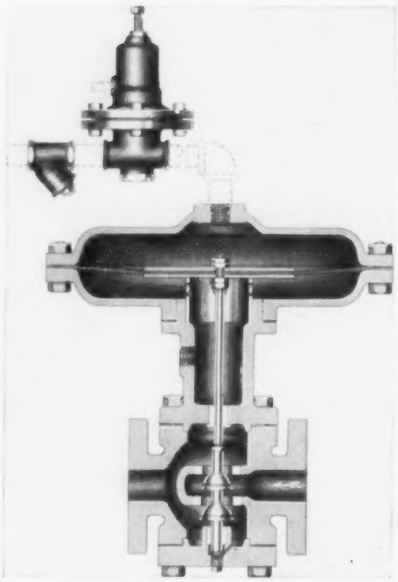


Gas Pressure Regulator

Fuel economy and control of furnace temperatures are results claimed for a new gas pressure regulating valve developed by the McAlear Mfg. Co. Either air or clean, dry gas may be used as the operating medium. This medium is piped through the pilot valve to the top of the main valve diaphragm and is maintained by the setting of the pilot at a pressure slightly lower than that which is to be controlled by the main valve. The pressure to be controlled is piped from the downstream side of the valve to the lower diaphragm chamber, where, on increasing, it tends to close the valve. Conversely, a drop in the controlled pressure causes the operating medium above the diaphragm to increase the opening of the main valve. The valve is suitable for inlet pressures up to 100 lbs. and is said to be easily adjusted to maintain combustion pressures at any point from 4 ounces to 35 lbs. Two types of pilot valves are offered: one with screw adjustment for direct mounting as shown, and one with an adapter and composition hand-wheel for mounting on a panel board to permit centralized control of gas pressures to burners. Sizes ½" to 6".

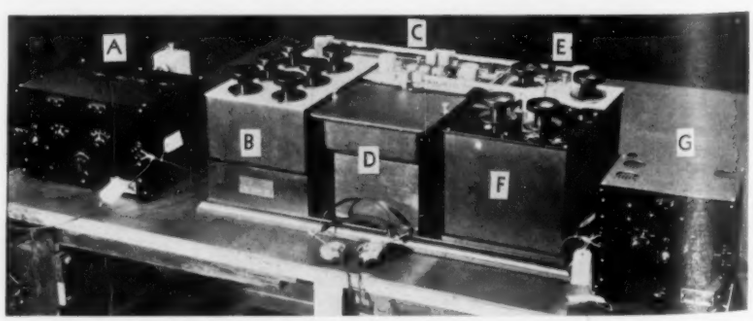
Contour Measuring Projector

Self-contained and said to differ from all previous instruments of its general class, the Bausch & Lomb Optical Co.'s new Contour Measuring Projector incorporates a completely new optical system, all elements of which, beginning with a new light source, have so been designed that the image formed is sharp from center to edge of screen, and corrections for color are "extremely good." Four objectives are provided (10×, 25×, 50× and 100×), all constructed to achieve absolute freedom from distortion, all instantly interchangable, and so adjusted

that the act of attaching them provides an image at exactly the rated magnification of the lens throughout the entire field of the screen. This makes for convenience and eliminates adjustments of magnification as a source of error in measurement. The screen is at eye-level and at about 18" from operator's eyes. The work table, located below and to the front of the screen, moves vertically for focusing and to accommodate objects of varying thicknesses. Vertical motion is accomplished by an electrically operated focusing device under accurate control of the operator. Another table permits measurement of objects in the plane of projection in two dimensions to 0.0001" and may be inclined for precise measurement of the constants of screw threads. Numerous standard and optional attachments and accessories make the apparatus universally applicable.

Shielded Capacitance and Conductivity Bridge

For rapid and precise measurements of phase angle of small (ASTM) samples of insulating oil, ceramics and other dielectrics; for calibrating other instruments; and for research applications requiring working to a few parts per million, a new assembly of a-c. instruments is announced by the Leeds & Northrup Co., its normal components (others optional) being shown in the condenser-calibration set-up illustrated: A—Oscillator No. 9842; B—Resistance Box No. 4765; C—Campbell-Shackelton Shielded Ratio Box; D—sample holder; E—Special capacitance-resistance box; F—Precision Air Condenser No. 1187; G—Amplifier No. 9847. The bridge assembly proper consists of B, C, E and F.



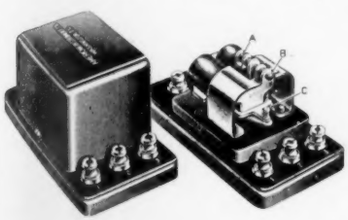
Illumination Analyzer

A new illumination analyzer consisting of a light meter and combination volt-meter-ammeter with suitable cable extensions, switches and plugs in a compact case for making a complete illumination analysis is announced by Westinghouse Electric & Mfg. Co. Watts input to the lighting circuit are measured by reading current and voltage: light output is measured with the "Photox" foot-candle-meter supplied as part of the outfit; the data obtained are thus complete, and efficiency

can be determined. The cell, which has a color response like the human eye, can be held in any position without disturbing the analyzer. The indicating instruments are equipped with knife-edge pointers and fine-line scale divisions. One is a microammeter calibrated directly in foot-candles; the other is a combination volt-meter-ammeter having scales of 0-3 and 0-15 amps. and 0-300 volts either a-c. or d-c. Ranges are selected by switches on the panel. The scale range of the light meter is 0-50 foot-candles. The analyzer comes with 8 ft. of cable for connection between Photox cell and instrument and 6 ft. of cable for connection to the power circuit. Cables are equipped with plugs and sockets for additional cable lengths.

Sensitive Relay

For use with mercury and bimetal thermo regulators and other devices with delicate contacts, the American Instrument Co.'s new "Aminco Midget" relay will operate also in the plate circuit of a vacuum tube, or in other high-resistance circuits. Contacts are rated at 1 amp. at



115 volts a.c. with armature adjusted for coil current of 7 ma. If operating current is increased to 15 ma. and armature spring tightened, as much as 2 amps. at 115 volts a.c. may be broken by the contacts. Mounted on a Bakelite base with a dust-proof Bakelite cover, the relay will operate in any position. Coil resistance is 800 ohms; minimum operating voltage 6 volts. Dimensions: 3⅞" ×2 1/16"×2 1/16".

Sound Level Indicator

Designed for use where extreme portability, and the ability to make rapid measurements are required, the RA-198 Sound Level Meter developed by Electrical Research Products, Inc., weighs 8½ lbs., measures 8¾"x5¼"x4¾", is intended to be held in the hand when operated (see illustration) and can be opened and a reading made in 10 sec. Simplicity of operation has governed the design: the scale of the indicator covers 18 db. so that the attenuator or "multiplier" need seldom be used. Other controls, intended primarily to compensate for decreases in battery voltage, require infrequent adjustment. The frequency characteristic is similar to that of the average human ear. The microphone, of a new type, is mounted in the face of the carrying case, and the cover protects it when closed.

Hour-register Time Meter

For totalizing running or idle time of electrical machinery or other equipment where a circuit may be opened and closed, the "Total Time Meter" is announced by the Westinghouse Elec. & Mfg. Co. This new instrument has four dials and will register 9,999 hours (approximately 400 days) before repeating. It can also be furnished with a special register providing one revolution per hour of the sweep hand. The sweep hand dial is then divided in tenths of an hour, and the register reads up to 9999.9 hours. The self-starting 120-volt, a-c., 60 cycle, synchronous motor is of the slow-speed, sub-synchronous type, with jeweled bearings. All parts, such as the register, motor, etc., are readily removable for inspection, repairs or replacement. The 11-volt and 120-volt styles require approx. 1.5 watts for operation. The 240-volt style requires approx. 3 watts. The synchronous motor will stay in step with voltages 12% above or below normal values. The two-piece Moldarta case has a 3½" flange diameter and overall length of about 3¼".

SHALLCROSS
Wheatstone Bridge

This Wheatstone Bridge, built around a highly sensitive galvanometer and Shallcross resistors, provides a simple and rugged yet accurate instrument capable of resistance measurements from 0.01 ohms to 11.1 megohms.

Send for Bulletin No. 630-H describing this instrument.

SHALLCROSS MFG. COMPANY
Electrical Measuring Instruments and Accurate Resistors
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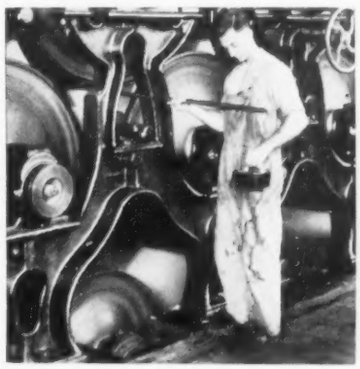
THWING
Surface Temperature Pyrometer



Taking surface temperature reading of revolving mill roll.

The Thwing Surface Temperature Pyrometer is used to take temperature readings of all kinds of flat and curved surfaces.

This pyrometer is very valuable for quickly taking temperature readings of hot billets, sheets, plates, mill rolls, corrugated rolls, bearings, etc.

Made in portable type as illustrated and stationary type for permanent mounting to secure graphic temperature record on a chart.

425

Thwing Instrument Company
3323 Lancaster Avenue, Philadelphia, U.S.A.

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A Symposium on Illumination. Edited by C. J. W. Greyerson. Instruments Publishing Co., Pittsburgh, 1935. Cloth, 5½x8¾ inches, 229 pages. Price $4.50 postage prepaid.

In making the following comments the reviewer has tried to look at this volume from the viewpoint of the average engineer. Although some passages are difficult to readers unfamiliar with trigonometry, etc., all chapters can be understood in regard to fundamentals by any adult possessed with some curiosity and a little patience.

Each chapter, originally a complete lecture, could be expanded into some half-dozen one-hour discourses (so succinctly is the information presented) but the average engineer or technical student should read this volume to gain a perspective of a plurality of subjects before taking up the detailed study of any of them.

The multiplicity of authors makes for variety of thought and expression, elimination of commercial prejudices, and of course explicit acquaintanceship with each topic. The reviewer can vouch for their authoritative standing, being personally acquainted with most of them.

Chapter I. Lighting in the Service of Mankind. By C. C. Paterson. In the pleasant language of a seasoned scholar one is told how our interest and concern in lighting have grown with the years. Radiations are simply expressed and compared with the octaves of a piano. A wider appreciation of the principles of light in its several fields is suggested. One is made conscious of the great unprospected future and of the need of more achievements. "In reviewing the evolution of illumination . . . we may think our own achievements wonderful, but let us beware lest our successors be able to say of us 'Illumination had they, but no insight; much light, but little vision!'" The reader is introduced into the reasons for lighting in industry and for street traffic safety. Good photographs illustrate the latter story.

Chapter II. Radiation, Light, and the Eye. By J. W. T. Walsh. Introduction to the romance of waves and vibrations as a physical equivalent of light and to the explicit designations of color, quantity, brightness, etc. The measurements of candle-power and the charting thereof contain useful short cuts, notably the Russell angles for determining the quantity of light from a polar diagram. Some readers may be unable to follow an occasional bit of simple mathematics but cannot fail to find good references in tables of color temperatures.

Chapter III. Electric Lamps and Their Characteristics. By W. J. Jones, readable condensed exposition of the performance of various materials used to transfer heat into light. Those interested in the characteristics of filament lamps will enjoy the discussions of the reasons why the modern lamp is made as it is. This chapter should be read by all persons dealing in incandescent lamps, including fixture designers and decorators. Tabulations of lamp efficiencies, life and light output, temperature and color transmissions of bulbs, would seem to be useful for ready reference.

Chapter IV. Gas Lamps and Their Characteristics. By F. C. Smith. Perhaps this chapter possesses the least applicable information but it is a good exposition of engineering principles bearing on the performance of gas burners and mantles. Particularly valuable are data on the distribution of radiation from mantle burners and some ex-

Inspection Microscope

Designed for rapid inspection of paper, metal, etc., the Gaertner Scientific Corp.'s new "M-128" Pocket Microscope is provided with self-contained illumination in the form of a standard fountain pen flash-light, and is especially adapted for the inspection of flat surfaces, as it may be removed and replaced without

refocusing. The optical system consists of two achromatic objectives and an achromatic eyepiece, which furnish four different magnifications, depending on their use and position:

Objective	*Mag.*	*Dia. field*
3a	35×	4.2 mm
3c	65×	2.3 mm
3a+3b+3c	80×	1.8 mm
3b+3a+3c	105×	1.2 mm

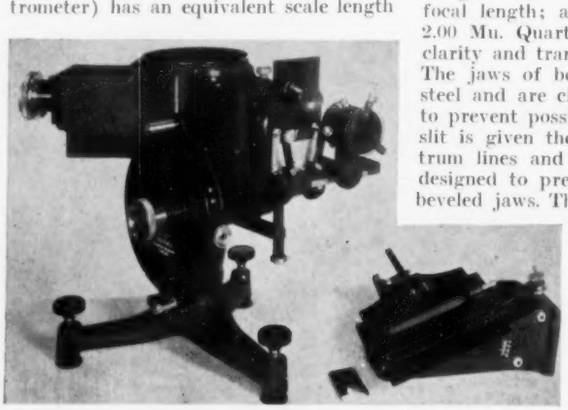
Magnifications of 75×, 120×, 145× and 195× can be obtained with the addition of an extension tube. Both the microscope and flash-light can be removed from the housing for separate use. A solid mounting, however, is recommended for all magnifications except the lowest.

Inspection Polariscope

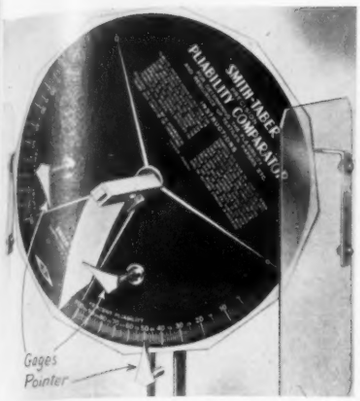
The Gaertner Scientific Corp. announces a new Strain Inspection Polariscope especially designed as a portable glass strain testing unit of large capacity to accommodate plates 14" diam., tubing 5" diam. of any length, and bottles and flasks up to 1-gal. capacity. Weighing 4¾ lbs., it collapses to 1¾"x11½"x 13½" to fit a regular brief case; and when set up it has a maximum height of 10½" and a length of 22". The curtains, attached by snap fasteners, may be removed for cleaning or for applications where they are not required. A 6" concave mirror provides a large polarized field which is viewed through a special analyzing eyepiece and a selenite plate. The light enters through a ground glass at the back which may be illuminated by any convenient light source or by daylight. Internal strains are evidenced by strong differences in light intensities and by brilliant colored bands. An unstrained sample does not affect the passage of light through it.

Universal Quartz Spectrometer and Monochromator

This new apparatus, the Gaertner Scientific Corp.'s "L-234-HT," is said to be an instrument of exceptionally high transmission and spectral purity, for use as a wavelength spectrometer or monochromator for a spectrum range of 0.185 mu in the ultra-violet to 2500 mu in the infra-red. The flat spiral dial (as used in the Gaertner wavelength spectrometer) has an equivalent scale length



of 2.4 m. with almost equal divisions over the entire scale. The exit slit can be replaced by the camera attachment illustrated at the right to provide a spectrograph capable of photographing wide stretches of any part of the spectrum without doubling. The design with one movable arm is said to make possible many desirable features, whereas the need for a fixed arm type is seldom imperative. The optical system being reversible, one can mount the light source on either the fixed or movable arm. A special accessory condenser system can be provided where neither light source nor radiated object can be moved. The dispersing element is a Cornu prism (32 mm. high, face length 56 mm.) its component parts held in optical contact. Objectives are quartz, of aspheric design, 32 mm. aperture and 150 mm. focal length; aperture ratio of F/4 at 2.00 Mu. Quartz parts are selected for clarity and transparency below 2.10 mu. The jaws of both slits are of stainless steel and are closed by spring pressure to prevent possible injury. The entrance slit is given the curvature of the spectrum lines and the straight exit slit is designed to prevent reflection from the beveled jaws. The objectives are focused with calibrated wavelength drums. The movable arm carries a bracket with a slide having lateral rack and pinion motion and a scale. To this can be attached spark terminals, the luminous element of a quartz lamp, thermopile, bolometer, absorption cell, microscope slide, etc. The prism table is linked to travel at half the rate of the moving arm. The telescope arm is moved by a nut which travels on a fixed screw, to which is fastened the flat spiral wavelength dial. A transparent uranium glass with an engraved cross hair is furnished with an inclined ocular fitted onto the slide which permits viewing the pure fluorescence of the glass without directly radiating the eye.



Pliability Comparator

Development of a quick and accurate means of determining pliability of textiles, thin papers and leathers, transparent wrappings, etc., is announced by the Smith-Taber Co. *Operation*: sample is placed in clamp, dial rotated, reading taken when sample touches gage; procedure repeated against opposite gage: average is pliability in one direction referred to grain. Clamp is loosened, sample turned 90° and two readings again taken. To determine elastic properties, test procedures involving time factors are followed. The Pliability Comparator helps also to determine "softness"—a complex function of various quantitative and qualitative properties.

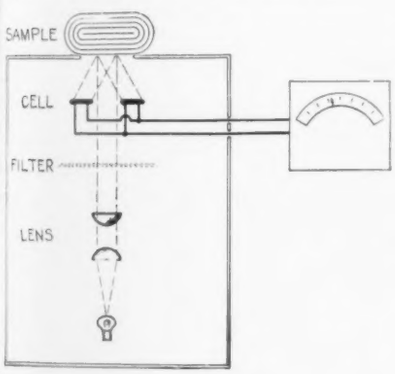
Voltage Regulator

A manual voltage regulator known as Voltrol, developed by The Acme Elec. & Mfg. Co., comprises a specially designed auto-transformer to which the primary line voltage is supplied. A non-burning contact mounted on a travelling arm taps each turn of the winding to supply the

desired secondary voltage: 0 to 130 volts. The transformer and all connections are contained in a ventilated steel case on which is mounted the regulating knob. A voltmeter indicates the secondary voltage adjustment. One tumbler switch controls the primary voltage; another changes the secondary voltage from high to low range. Regulation is claimed to be accurate to <0.5 volt.

Color Comparator

Increasing use of colored materials in industry creates need for quantitative methods of reproducing colors. The complexity of the problem results from the fact that color stimulus reaching the eye is a summation of many factors which the eye has no power to differentiate. The most complete scientific method of color analysis consists in surveying the entire visible spectrum and measuring the intensity of each frequency in the complex waveform in the same manner as wave analyzers are used at low frequencies. Complete analysis, while essential for standardization, is relatively costly and complicated when considered for the shop. The engineering firm of Barss, Knobel & Young have evolved a simplification of the analyzer principle; and the General Radio Co. is manufacturing it as "Type 725-A Color Comparator." Reflection is measured in three frequency bands selected from the complex waveform by filters. The sample is placed over the viewing aperture and milliammeter readings obtained corresponding to the red, blue, and green regions. When these readings are identical for two samples, the samples are identical in hue, saturation, and brilliance; and will match under any conditions of lighting when viewed by reflected light. An optical system has been devised which eliminates the "direction-of-light" and the "glare" errors. In operation, the instrument is set up and calibrated with a magnesium-oxide sample over the viewing aperture: shunts are set to give standard deflection for each filter. The sample is then placed over the aperture and the three



readings taken. The Color Comparator can be used also to measure the opacity of paper, the method of the Institute of Paper Chemists being followed. No amplifiers are required. The scale is wide and open, permitting determination of small color differences. A voltage regulator is built into the instrument, which is entirely operated from a-c. mains. Power consumption, 75 watts; dimensions, 16″ × 12″ × 12″; net weight, 40 lbs.

Surface Temperatures

Flat Stationary or Moving Curved Surfaces

The "Alnor" Combination Pyrocon

Ideal for rolls, molds, plates, platens and plastic material temperatures.

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Illinois Testing Laboratories, Inc.

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ELECTRICAL INSTRUMENTS

METERS—PYROMETERS

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H. F. BYRAM

28 Bathgate Pl. Newark, N. J.

planations of the performance of earth oxides used in the Welsbach mantle.

Chapter V. Daylight, Colored Light. By J. W. Walsh. The author's simple discussion of this interesting subject would seem fundamental to any comprehensive knowledge of artificial lighting. Beyond the boundaries of illuminating engineering, most every schoolboy could and should enjoy the story of sky brightness, of daily and monthly variations of sunlight quality and quantity; of effects of clouds and fogs and of the ephemeral nature of natural colors. The inadequacy of interior daylight is touched upon sufficiently to suggest a further study of that problem.

Chapter VI. Photometric Standards, Lamp Photometry, and Illumination Measurements. By J. T. MacGregor Morris. The subject is too vast for some two dozen pages of text. Several fundamental designs of laboratory photometers are described with suggestions of mechanical details as practised in one particular college. Perhaps the condensed paragraphs would suffice the average reader who would not have occasion to work in the laboratory. Had space permitted, many more instruments could undoubtedly have been described —especially the portable types of field photometers.

Chapter VII. The Redistribution of Light. By G. H. Wilson. The author introduces the idea of the effects of filament forms on the distribution of light radiating from a lamp bulb. He gives several examples of short-cut calculations that tie the reflector to the amount of light on the illuminated plane. Sufficient discussion of reflector contours is given to enable the construction of a simple lamp accessory. Reference tables are offered that list distribution of flux from different types of equipment. Foot-candle intensities as given, since they are changeable with increased knowledge of usage, would have to be modified from year to year but the general characteristics of reflectors are fairly well covered. Tables of data useful in designing the spacing and mounting of filament type illuminants form ready references.

Chapter VIII. Lighting for Decoration and Entertainment. By A. B. Read. Of special interest to the architect. More complete treatises should be read if one cares to learn of lighting for amateur theatricals, of cares to plan such classes of decorative lighting as included in the outdoor field of floodlighting, garden lighting, and sports lighting. The chapter presents the background and arouses interest in the subject.

Chapter IX. Public Lighting. By J. F. Colechus. A brief history is followed by interesting data on the expenditures in a typical industrial city where

street lighting is chiefly a matter of protection and safety. Some remarks are given on automatic control and operating features and some fundamental comments on glare and visibility. The classification of streets under the British standard specification is interesting and a tabulation of the details of street lighting in Sheffield, Birmingham and sections of London would be interesting to compare with not dissimilar data for corresponding American cities.

Chapter X. Lighting for Safety, Health and Welfare. By H. C. Weston. The author discusses the always important effect of light and vision on accidents, upon fatigue and upon production. Comments on visual acuity bring into this story a few suggestions on optical hygiene and refractive aids to the human eye. S. H. Hibben (7.1)-B-

Technical-Physical Practice (Technisch-physikalisches Praktikum). By Osc. Knoblauch & We. Kock. Verlag Julius Springer, Berlin, 1934. Cloth, 6⅜x9⅜ inches, 167 pages. Price 13.50 RM.

The sub-title (General investigation methods of technical physics) gives an exact description of the book; essentially temperature measurement and in addition several mechanical and sound measurements, are covered. Under temperature measurement is covered the calibration of simple and special temperature measuring instruments, also a number of important industrial temperature measurements, for example surface temperature, temperature of rotating rolls, of gases, etc. The determination of heat conductivity of heat resistant and construction materials is discussed. Other measurement methods are devoted to heating, for example the determination of radiation values at ordinary temperatures under operating conditions, the investigation of heat given off by radiators, etc. Under mechanical measurements there are several measurements of pressure and speed, for example air penetration, including the calibration of suitable micromanometers, volume measurement by pressure drop in pipes, in addition to damping by rubber and cork plates. The section on accoustic measurements is mainly concerned with absorption of various materials, carried out on small samples.

The treatment is distinctive in that the authors start with the problem, giving the theoretical bases and conceptions and then develop the particular measurement methods necessary, due to the special conditions of the problem. (1.2)-B-

Objektive Photometrie. By Rudolf Sewig. Julius Springer, Berlin, 1935. Paper, 6½x9½ inches, 193 pages. Price 19 RM.

This little book has a distinctly practical aim, which is to describe those instruments which are most useful and most readily available for the engineer who has occasion to measure light by objective methods. The rapid increase in the use of physical "photometers" in routine measurements makes the volume timely. The title is somewhat misleading since the book does not pretend to give an adequate discussion of the principles of photometry. In fact, one might wish that the photometric significance of the measurements made by the various instruments were set forth more clearly.

In general, then, the work is not an exhaustive treatise but rather a readable exposition of the present status of instruments in this field. The survey of the various classes of apparatus sensitive to light (thermoelements, bolometers, photocells, photo-resistances and sperrschicht-elements or blockinglayer cells) and the auxiliary electrical and optical devices used with them will be helpful to those who have to choose equipment for particular purposes. This usefulness is made greater by the specific references to types of apparatus which are commercially available. Naturally, the instruments specifically mentioned are in large part German, but the leading manufacturers in other countries are not entirely overlooked.

The work is well illustrated, having 140 figures. The typography and general make-up are excellent.

E. C. Crittenden (7.1)-B-

Universal Tester

A new universal tensile strength tester for paper, cordage, light wire, rubber, and other flat materials has been added to the line of the Amthor Testing Instrument Co. Conforming to standard specifications, the machine operates on the pendulum principle. Elongation tests are made simultaneously with tensile strength tests. There are two quadrant scales: one for load, the other for elongation. A straight vertical scale is provided for rubber elongation.

The load scale has two graduations which are made to specifications: one covers the entire capacity of the scale, while the lower range gives finer readings for delicate materials. The machine is motor-driven, with variable speeds of the pulling clamps which are standard for various materials. Clamps for paper, cordage, rubber, light wire, etc. are interchangeable and may be adjusted to the desired clamp distances. Limit stops are automatic. A floor model with cabinet, and a bench model, are available.

Universal Impact Tester

Said to be "the most universal of all impact testers built," this new machine brought out by Riehle Testing Machine Div., American Machine & Metals, Inc., is always ready for either a Charpy or an Izod test—no exchange of hammers or renewal of anvils being necessary. This has been made possible by a combination hammer of novel design: its profile and shape enable it to pass with ample clearance the Izod anvil (the hammer is split for this purpose) and also the Charpy anvils, so that the only conversion necessary when changing from one test to the other is to replace the striking edge in the hammer. Mountings and measurements are such that in vertical balance of the pendulum hammer the point of the Charpy or Izod striking edge just touches the inserted Charpy or Izod specimen at the proper distance in relation to the anvils. The standard Charpy 10x10 mm. specimen tested on a 40 mm. span rests on the horizontal supports which hold it in place on the anvils, is placed on the anvil with the notch away from the striking edge and directly on line with it. Anvil blocks for specimens sizes up to 30x30 mm. and up to 140 mm. span may be had specially. The Izod specimen is clamped in a vise secured to the base of the machine with the notch toward the striking edge and even with the top of the vise (striking edge 22 mm. above top of holding vise). For 220 ft.-lbs. the pendulum is raised to a starting position of about 20° from vertical; for 110 ft.-lbs. to about 1° below horizontal. The pendulum hammer is suspended on "high-grade ball bearings of very small diameter entirely sealed in," and is thin in the plane of motion to minimize windage drag. Complete elimination of energy-absorbing vibration in the machine itself is said to have been accomplished. The anvil effect is not dependent on the foundation. Makers lay stress on conformity to latest national and international standards.

Time Controllers

The Walser Automatic Timer Co. announces two new models suited particularly for short time intervals. (1) "No. 59 LA" (Fig. 1) is provided with two levers, one of which fixes the timing interval and the other simultaneously closes the switch and starts the timer mechanism. The timing lever may be permanently set or readjusted at will. This is the type familiarly known as the "toaster timer." Stock timing range 5-minute max.; others up to 9-minute max. Switch is of silver contact type; double-pole double-throw is standard but it can be supplied with single-pole contacts, and timer so wired. This timer is adapted for two-heat household appliances, etc. (2) The No. 10LC, entirely new, meets the demand for a switch-equipped single-lever timer of short time range. Its operation is simple, the switch-setting and starting lever being also the time setting lever. The timing interval depends upon the distance of the lever throw. Two timing ranges: 5 minute max. and 1½ minute min.; and 50 sec. max. to 13 sec. min. A bell clapper is provided when required for signaling the end of the timing interval.

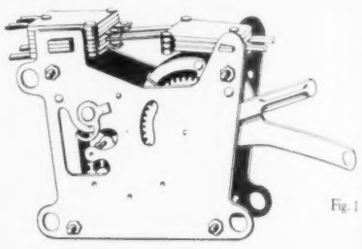


Fig. 1

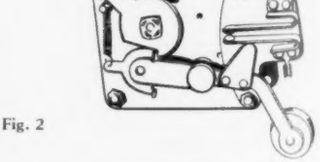


Fig. 2

Photoelectric Reflection Meter

Designed by Dr. B. Lange of the Kaiser Wilhelm Institute, an instrument for the determination of "whiteness," offered by Pfaltz & Bauer, Inc., is distinguished by a combination element (Fig. 1) wherein a central light-source and an annular self-generating photocell are always in fixed relation to each other and to the surface of the specimen, so that the photocell output bears a reliable relation to the property under measurement. In addition to reflection measurements, colorimetric analyses may be made with the aid of filters supplied with the outfit (Fig. 2) which includes a microammeter for photocell output, a small Edison storage battery, a volt-

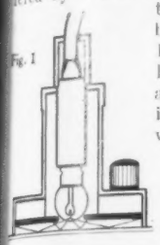


Fig. 1

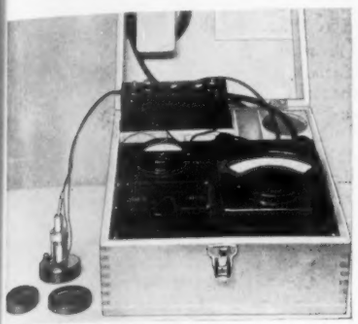


Fig. 2

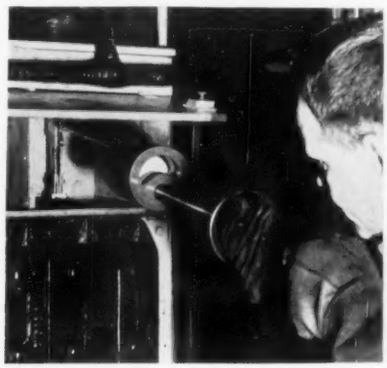
meter for standardizing the light source, two rheostats, a rectifier, dishes for measurements on powders, and standard black and white plates for determinations of transmissivity and opacity. Always ready for use with or without an available commercial source of electric energy, the apparatus is said to meet requirements of the ceramic and other industries.

Precision Water Gage

A self-contained electric water gage, said to supplant hook gages for measuring water level to 0.001 ft., has been developed by the R. C. Burt Scientific Laboratories in coöperation with engineers of the U. S. Forest Service. The scale of the "Millipoint gage" is a stainless steel tape wound upon an insulated brass spool within the case, and connected through a resistance, a milliammeter, and a switch to a 4½ volt battery grounded to the case and thence to a ground connection in contact with the water, the height of which is to be measured. To measure a level, the tape is unwound, thus lowering a plumb bob until its stainless steel point makes contact with the water, closing a circuit and causes the needle to jump. The tape is then read. Certainty of first contact in the water circuit is assured by sensitivity to 0.00001 amp. The tape on "Type 25 Millipoint Gage" is 25 ft. long, and the vernier reads to 0.001 ft. The unit is housed in a cast aluminum case 10"x7"x6", weighing 7 lbs., for either wall or shelf mounting. Various tape lengths are available.

Surface Temperature Checker

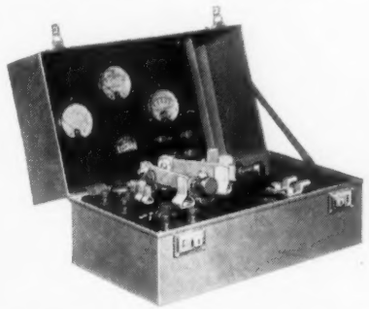
Rapid in operation and entirely self-contained, the new "Type WP" Temperature Indicator offered by Schweitzer & Conrad, Inc., is a portable thermo-electric pyrometer of lance form, cali-



brated to indicate the difference between the temperature of the tip junction and that of the reference junction—the latter always being the ambient temperature, so that readings are representative of inherent and not of external heating effects, thus rendering the instrument especially suitable for checking temperatures of buses, transformers, motors, etc. Insulated handle and guard permit use on 23-kv. system equipment.

Circuit Tester

Portable (27 lbs.), self-contained and designed for industrial electricians, field engineers, master mechanics, building equipment inspectors, etc., the Leonard Elec. Mfg. Co.'s new "Model 3-DA" cir-



cuit tester is adapted to measuring currents and voltages in circuits < 100 h-p., < 250 amp. a.c., < 300 amp. d.c., < 600 volts. The set is "not just a box of loose parts" but a planned assembly with shunts, resistors, etc., concealed and permanently connected; cadmium-plated switching mechanism; compartment for tachometer, leads, etc.; 4-scale voltmeter; 3-scale a-c.-d-c. ammeter, etc.

MANUFACTURERS' NEW LITERATURE

In this department we list each month the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

C224 **Small Panel Instruments.** A new 8-page bulletin describing panel-type electrical measuring instruments has just been issued by the Weston Electrical Instrument Corp., Newark, N. J. The bulletin includes specifications, dimensional drawings, illustrations and prices for the 2, 3 and 4-inch line of instruments in both the round and rectangular types. Specifications are given for the following instruments: d-c. voltmeters, ammeters, milliammeters, microammeters, ohmmeters, volt-ohmmeters, high sensitivity microammeters; a-c. voltmeters, ammeters, milliammeters; a-c. (rectifier type) voltmeters, milliammeters, microammeters; Wattmeters; Thermo-instruments. Information concerning the new line of 3-inch rectangular panel instruments recently announced by the Weston organization is a feature of the bulletin.

C225 **Test Light and Fuse Puller.** Ideal Commutator Dresser Co., of Sycamore, Ill., has issued a leaflet covering a Combination Test-Lite and Fuse Puller with 18" flexible leads.

C226 **Oil Tools.** The Lane-Wells Co., 4439 Santa Fe Ave., Los Angeles, has just completed a 74 page catalogue containing bulletins on packers, liner hangers, and gun perforator service. An interesting feature of the catalogue is the exceptionally complete "applications" section in each bulletin, containing (in addition to the better known uses) information on many practical applications of each product not generally known to the industry at large.

C227 **Laboratory Gas Testing Apparatus.** 16 pages covering: the American Calorimeter; Referees' apparatus for Sulphur and Ammonia Tests; Hydrogen Sulphide Test Apparatus; 1/10 Cubic Foot Bottle; 1/10 Cubic Foot Wet Test Meter; Double Dry Governor; American Laboratory Dry Governor; Specific Gravity Apparatus; Improved Portable Schilling Apparatus; and New Recording Gravitometer. American Meter Co., 60 East 42nd St., New York, N. Y.

C228 **Indicating and Recording Gages for Draft, Pressure and Temperature.** Catalog PGA-35, 24 pages, describes the complete Hays line of Dry Type Pointer Draft Gages; Inclined Tube, Direct Reading, U-Tube and Vernier Scale Gages and Dry Type Draft Recorders. Hays Corp., P. O. Box 299, Michigan City, Ind.

C229 **Controlograph for Temperature and Pressure.** The features of this device are listed in a 4-page folder. Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

C230 **Simplified, Two-Position Micromax Controller,** is the title of Catalog Sec. NC 24A. The instrument here described has neither indicating nor recording devices, but is a simplified controller. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

C231 **Thwing's Foundry Visitor.** The Thwing Instrument Co., 3339 Lancaster Ave., Philadelphia, Pa., have recently issued Vol. I, No. I, June 1935, of a house organ which promises to bring "Interesting Journeys to Interesting Foundries." The first visit is to the American Manganese Bronze Company.

C232 **Thermocouple Head.** Leaflet lists advantages of the Gordon Thermocouple Head TH-125. Claud S. Gordon Co., 708 West Madison St., Chicago, Ill.

C233 **Pilot Safety Switch.** 4-page folder describes the Klixon C-1888 switch. The operation and installation is also covered. Spencer Thermostat Co., Attleboro, Mass.

C234 **Thickness Measures, Pocket Gages and Dial Micrometers** of B. C. Ames Co., Waltham, Mass., are beautifully illustrated by full size photographs in an 8-page bulletin.

C235 **Diaphragm Valves.** Bulletin No. 1117 gives specifications and engineering data on Tag diaphragm valves. Seven charts give valve capacity data and make precise selection of valves possible.

C236 **Boyle Velometer.** Bulletin 2126 describes this instrument which is an instantaneous direct reading air velocity meter. Illinois Testing Labs., Inc., 420 North La Salle St., Chicago, Ill.

C237 **Electric Temperature Control.** Leaflet illustrates the Models M and MRR electric temperature controls. Partlow Corp., New Hartford, New York.

C238 **Wire Measuring Gage.** A recording wire gage consists of a Federal Model 493 continuous insulated wire measuring gage and a special Foxboro recorder. Federal Products Corp., Providence, R. I.

C239 **General Radio Experimenter.** The 2 most recent issues of the *Experimenter* (June and July 1935) are very interesting. The June issue is devoted to "A Review of Twenty Years of Progress in Communication—Frequency Measurements." The July issue describes: Wide-Range Transformers and Best Frequency Oscillators. General Radio Co., 30 State St., Cambridge A, Mass.

C240 **Microscope Accessories.** 48-page book covering: microscope objectives, microscope eyepieces, ampliplans, special eyepieces, monocular eyepiece holders, binocular eyepiece holders and bodies, substage condensers, camera lucidas, nosepieces, attachable mechanical stages, micrometer discs, micrometer eyepieces, stage micrometers, counting chambers, haemacytometers, Richards-Roope tangent meter, object slides, cover glasses, slide boxes Suter thread carrier and textile cross section mount. Bausch & Lomb Optical Co., Rochester, N. Y.

C241 **Johansson Gage Blocks.** Catalogue No. 11, a 36-page catalogue describing the various standard sets. A table lists the individual standard size gage blocks. Ford Motor Co., Johansson Div., 3674 Schaefer Road, Dearborn, Mich.

C242 **Impact Tester.** 4-page bulletin describes a combination Izod, Charpy and Tension Impact Tester, 110 and 220 ft-lbs. capacities. Riehle Testing Machine Division, American Machine & Metals, Inc., East Moline, Ill.

C243 **Radio Servicing Instruments.** Price Sheet No. 38 gives prices on Master Unit Testers; d-c. voltmeters, millivoltmeters, milliameters and micrometers; volt-ohm-milliammeters; resistance instruments; output meters, relays, etc. Triplett Electrical Instrument Co., Bluffton, Ohio.

C244 **Paper Testing Instruments.** 4½-page bulletin describes the following: paper-surface tensile strength tester; paper scratch tester and paper hardness tester. R. Fuess, Inc. 245 West 55th St., New York, N. Y.

C245 **Alnor Temperature Measuring Instruments.** 12-page leaflet illustrating and describing the complete pyrometer line of the Illinois Testing Laboratories, Inc., 420 North La Salle St., Chicago, Ill.

C246 **Direct Reading Brinell Machine.** Leaflet illustrates this new development of the Detroit Testing Machine Co., 5137 Trumbull Ave., Detroit, Mich.

C247 **Spectrophotometer Assemblies.** Bulletin 134 Supplement illustrates diagrammatically the spectrophotometer assemblies for the determination of absorption coefficients and reflectivity. Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.

C248 **Pyrometer Records in both Color and Number.** Bulletin gives an actual size record from a 4-record potentiometer recorder. Foxboro Co., Foxboro, Ill.

C249 **Hygrometers and Psychrometers.** 2 page bulletin 6042 covers the Mason Form Hygrometer, Humidiguide and sling psychrometer. Taylor Instrument Cos., Rochester, N. Y.

C250 **Radio Service Instruments.** 16 advanced 1936 models are illustrated by condensed catalogue inserts. Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.

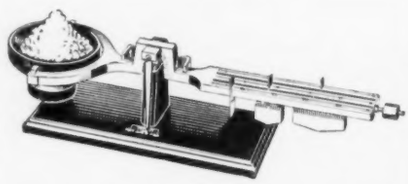
R-f. and A-f. Oscillator

A built-in output indicator distinguishes the new "OS7" Oscillator brought out by The Hickok Elec. Instrument Co. and is said to be one of eight exclusive features, others being: practicability of stage-by-stage alignment and check;

direct-reading dial to 40 Mc.; inclusion of a variable a-f. signal generator; a r-f. corrector said to assure extreme precision of calibration and to permit accurate selectivity measurements; the circuit equivalent of five tubes; output continuously variable in two ranges from <0.1 microvolt to >0.1 volt; output indicator automatically connected into receiver at proper circuit.

Portable Balance

To meet the demand for a small-capacity scale of such low cost that it can be supplied in quantities to traveling men or to numerous men in one establishment, the Chemical Publishing



Co. has brought out the Bennett ("U-carry-It") Balance which has a capacity of 100 g. and a sensitivity of 0.01 g. Its length is approx. 12″; its weight <1 lb. *Features*: alloy steel knife-edge and agate bearing; beam arrest; no loose weights; can be carried in a coat pocket.

BOYLE VELOMETER

Instantaneous Direct Reading Air Velocity Meter

20-feet to 6000-feet per minute

Write for Bulletin

Illinois Testing Laboratories

Incorporated

142 W. Austin Avenue

Chicago, Illinois

Speed-regulating Resistors

A new unit method of assembling, wiring, and shipping speed-regulating resistors for large a-c. wound-rotor motors, which saves as much as half the space previously required, and facilitates installation work, is announced by the General Electric Co. All resistor grid boxes for each drive motor, instead of being supplied separately, are mounted in a fan-cooled sheet-metal cabinet with a convenient terminal board on the outside. Positive ventilation makes fewer grids necessary. The grid boxes are wired at the factory to provide the motor speed characteristics desired, and marked terminals are connected to match up with those on the control panel. Units are shipped completely assembled, with no additional racks or supports required. They are also easily disassembled should conditions ever require them to be. The noiseless-type fan operates only when the drive is running.

Spectrogram Comparator

A new comparator of the traveling-microscope type announced by the Gaertner Scientific Corp. as "M-1176" was especially designed for measurements on spectrograms. Its stage holds plates up to 4″x10″ and its 4″ diam. micrometer head permits reading to vernier to 0.001 mm. (a certificate of accuracy of the micrometer screw is provided). Magnifications of 5× to 42× are available by means of the two objectives and two eyepieces supplied with the microscope. A plane mirror for illumination is attached beneath the stage.

Phantom Loads

The States Co. announces two new series of phantom loads: "Type F" designed for regular watthour meter testing, and "Type FD" for use in testing on extended duty cycles, as in demand meter testing. Both are built in 25 and 50 amp. capacity; Type F also in 75 amp. capacity. They are said to combine excellent

wave form and comparatively light weight especially in the Type FD with a duty cycle sufficient for prolonged test period. There are 13 current steps for the 25 amp. loads and an additional 50-amp. step for the 50 amp. load. A series parallel switch included in the primary circuit affords simple operation, reduces liability of wrong connection and makes possible a compact arrangement with all connections on the top of the load.

Welding-time Recorder

Designed for use with resistance welder timers and other fractional-second time-recording applications, the General Electric Co.'s new "Cycle Recorder" records, on a paper tape, the a-c. cycles of duration of current flow. It comprises a frequency-responsive element, marking mechanism, paper-tape drive, and paper tape supply. The frequency-responsive element is a polarized reed driven by an encircling coil tapped for use at either 1 or 5 amps., although a

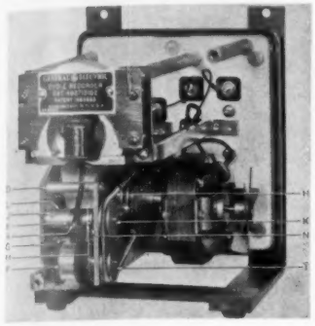


Fig. 1

110-volt coil can be obtained if desired. The recording device is inkless: a stylus carried by the vibrating reed presses lightly on the moving strip of extremely thin paper under which rotates a graphite roll. The record can be read from either side of the chart. A small a-c.

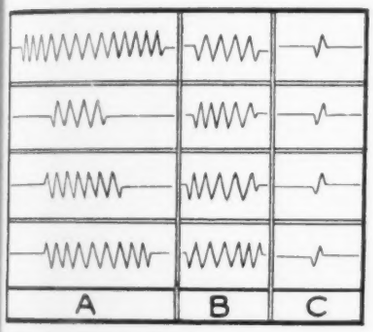
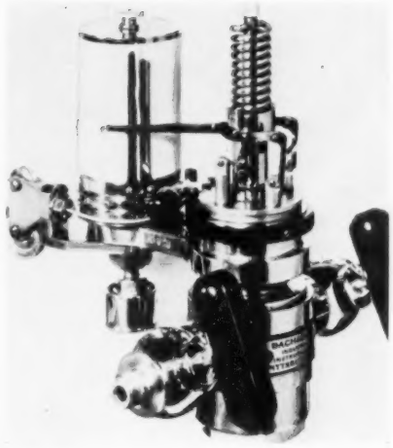


Fig. 2

motor drives graphite roll and feeds recording tape. The instrument, easily operated and sturdily built for field use, measures 5½"x7½"x7½". Fig. 2 shows (A) four records of an inexperienced welder's work, (B) four of a skilled man's and (C) four of a welding machine equipped with electronic control.

Piston Type Differential Pressure Recorder

Designed along the lines of an engine indicator, a new type of recorder developed by the Bacharach Industrial Instrument Co. for measuring rapidly fluctuating differential pressures consists essentially of cylinder, lapped piston, helical spring and recording drum. The latter may be rotated by the mechanism under test (so that pressure is recorded as a function of a certain reference motion) or driven by a spring-wound clock. Available chart speed ranges: 7 to 72 in./min., 10 to 100 ft./min., 150 to 450 ft./min. Four intermediate speeds within each range. Design is such that the unit pressures acting against each piston side



are of equal value, and spring calibrated so that its load-deflection rate is directly proportional to differential. Consequently, piston movement under the action of the two variable pressures is a direct measure of the difference between them. Straight-line mechanism produces a magnification of 6×. User can place the zero at any point on the scale. (With zero at center, differential pressures are recorded on either side.) Interchangable pistons and springs give practically any pressure range desired.

Flow-rate Indicator

For indicating instantaneous rate of flow of liquids and gases in industrial applications where a conventional form of flowmeter seems too costly, and where low pressures and absence of water-hammer, etc., permit the use of an extremely simple device, Schutte & Koerting Co. has brought out the "Tubular Case Rotameter." Its characteristics are largely similar to those of more elaborate models (see *Instruments*, Aug. 1932, page 202; Dec. 1933, pages 222-225; April 1935, page 107; May 1935, page 136) but the stuffing boxes between the inner tapered glass tube and the slotted steel tube body cannot be tightened or re-packed without taking down the entire assembly. Sizes 1" to 4" are available. Fittings are cast-iron, bronze or aluminum (others special). Screwed connections standard; flanges to order.

Sand Strength Tester

A high dry sand strength accessory for "Type C.P." Universal Sand Strength Machine (see *Instruments*, March 1935, page 84) is announced by Harry W. Dietert Co. It affords a means of testing the dry strength of unusual molding sand mixtures. Capacity 300 lbs./in.², dry compression and 220 lbs. dry shear, sufficient to break specimens made from sand mixtures that possess exceedingly high dry strength.

C251 **Vacuum-Tube Voltmeter.** Form 14030-A is an 8-page Engineering Application Bulletin and contains a resumé of many convenient measurements that can be made with this instrument. Clough-Brengle Co., 1134 West Austin Ave., Chicago, Ill.

C252 **Jet Pipe Regulator.** Bulletin No. 100 discusses the Askania control and its principle of operation; construction of the Jet Pipe Regulator; and the regulating cylinders.

C253 **Electric Temperature Control.** 4-page folder illustrates several control types as well as several types of motor valves. Wilbin Instrument Corp., 40 East 34th St., New York, N. Y.

C254 **Industrial Thermometers.** Bulletin No. 1125, 24 pages gives engineering data on industrial thermometers including miscellaneous metal and wood back thermometers, also hygrometers, U-gages, mercurial vacuum gages, and mercurial barometers. C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y.

C255 **Resistance Bridge.** 4-page attractive folder gives the specifications and construction details of a Wheatstone Resistance Bridge, price $49.50. Muter Co., 1255 South Michigan Ave., Chicago, Ill.

C256 **Combustion Control for Boilers.** Data Book No. S-20 covers the subject of mechanical combustion control, discussing in detail: 1. the basic problems of boiler operation and their importance; 2. the difference between a control system and mere regulation; 3. the essentials of a successful mechanical control system; 4. numerous diagrams illustrating how mechanical control can be applied to various types of boilers and fuel firing equipment. Smoot Engineering Corp., 2240 Diversey Parkway, Chicago, Ill.

C257 **Stiffness Tester.** Bulletin No. 11 describes the Tour-Marshall Design, which has a capacity of 30 inch-pounds bending moment, designed primarily for light sheet and wire. Tinius Olsen Testing Machine Co., 500 N. 12th St., Philadelphia, Pa.

C258 **High Voltage Detectors.** Bulletin No. 214 covers the several types of detectors. This bulletin also covers phase flashers and list prices. Schweitzer & Conrad, Inc., 4435 Ravenswood Avenue., Chicago, Ill.

C259 **Centrifuge.** Small leaflet is devoted to the Chavant "Cyclone" centrifuge. Hasler-Tel Co., 461 8th Ave., New York, N. Y.

C260 **Thickness of Cadmium and Zinc Deposits.** Leaflet describes the Chemicrometer used for measuring the thickness of plated coatings. Method is explained. Plating Products Co., 352 Mulberry St., Newark, N. J.

C261 **Color Matching.** Leaflet describes the Telecolor for comparing color in ceramics, textiles, leathers, food products, medicinals, beverages, dyestuffs, inks, paints, etc. Telecolor Corp., Pawtucket, R. I.

C262 **Laboratory Clamps.** 4-page folder illustrates various clamp models of brass and stainless steel, claimed to have exceptional resistance to corrosion and increased strength. E. H. Sargent & Co., 155 E. Superior St., Chicago, Ill.

C263 **Industrial Crimes, Case No. 7.** Small booklet gives a case where time lost in plant is reduced 360,000 man-hours as a result of an investigation with graphics. Esterline-Angus Co., Indianapolis, Ind.

C264 **Densitometers.** List D9₁₀, 4-page leaflet the Martens-Goldberg and Martens-Bechstein polarization photometers for measuring the absorption, respectively blackness or density of photographic negatives. Akatos, Inc., 55 Van Dam St., New York, N. Y.

C265 **Balancing Machines.** Bulletin 737 describes the Hi-Eff balancer with automatic weighing scale and automatic calculator for perfect balance in rotating parts. Taylor Mfg. Corp., Milwaukee, Wis.

C266 **Temperature Controller.** Catalog 2200 gives specifications, ranges and prices for the American Precision Controller. Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.

C267 **Water Meters.** Bulletins M-975-B12, B13, B14, B15 and B16 lists the engineering features of disc water meters. Worthington-Gamon Meter Co., Harrison, N. J.

C268 **Flowmeter.** Catalog 1028A describes the Centrimox flowmeter which integrates first and then measures flow. Leeds & Northrup Company, 4901 Stanton Ave., Philadelphia, Pa.

C269 **Capacitors.** Bulletin GEA-77H supersedes GEA-77H discusses improvement of power factor. Bulletin includes description, wiring diagrams, dimensions. General Electric Co., Schenectady, N. J.

C270 **Radio Parts Reference Book.** A 92-page parts catalogue with technical information for the radio serviceman and dealer has just been issued by the RCA Mfg. Co., Camden, N. J., for selective distribution through wholesale RCA radio and parts distributors. In it are listed all of the numerous radio replacement parts and specialty apparatus with their electrical and mechanical characteristics and specifications so that the serviceman can get all the information he needs on a part or piece of apparatus at a glance. A particularly useful feature is the inclusion of an exhaustively cross-indexed chart of all the important replacement parts for the RCA Victor radio receivers and the corresponding models of the General Electric, Graybar and Westinghouse Companies, with stock numbers and prices. For handy reference, all the items covered in the catalogue are indexed and cross-indexed. Items intended for resale to the public are shown with retail list prices so that they may be sold to the customer direct from the catalogue if desired.

C271 **The Askania Jetpipe.** 16-page Bulletin 103, of the American Askania Corp., 1603 South Michigan Ave., Chicago, gives data on the Jetpipe control device, presented in question and answer style.

C272 **Multiple Pen Recorder.** Catalog 4057 describes the Autelco multiple pen recorder for recording time, duration, number and sequence of electrical and mechanical operations. Automatic Electric Co., 1033 West Van Buren St., Chicago, Ill.

C273 **Portable Tensile and Bend Testing Machine.** Folder lists advantages of using the machine and necessary operating instructions. Air Reduction Sales Co., Lincoln Bldg., New York.

C274 **Thwing's Foundry Visitor.** The second issue of this house organ issued by the Thwing Instrument Co., 3339 Lancaster Ave., Philadelphia, Pa., is devoted to the foundry of the Textile Machine Works, Reading, Pa.

C275 **Adjustable Orifice.** Bulletin 14, 4 pages, gives the characteristics of Bailey adjustable orifice. Distinctive features and construction details are covered. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

C276 **Air Operated Controllers.** Catalog No. 8900, 24-page booklet handsomely arranged and printed describes the Brown Air-o-line controllers for temperature, pressure, flow and liquid level. Brown Instrument Co., Philadelphia, Pa.

C277 **Air-Operated Combustion Control.** A 32-page bulletin entitled "Air-Operated Combustion Control" and designated as No. 102, is being distributed by Bailey Meter Company, Cleveland, Ohio. It describes a complete combustion control system which automatically maintains steam pressure, combustion efficiency and furnace draft; explains how the system ties in with the company's Boiler Meter to automatically readjust fuel-air ratio, thereby maintaining combustion economy and reducing furnace maintenance to a minimum. Diagrams show how the system may be applied to boilers from 200 h.p. up, fired with fuels in suspension or with stokers.

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C285 **Feed Water Regulators.** Bulletin No. 83, 16 pages, supersedes Bulletin No. 82. Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio.

C286 **Air Operated Process Control.** Bulletin No. 101, 16 pages describes control systems. Data include: Principle of operation, accurate controllers; air supply; free-floating pilot valves; selector valves provide manual control, and list of users. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland, Ohio.

C287 **Automatic Valves for Mixing Hot and Cold Liquids.** Bulletin No. 258 illustrates operation of valves for mixing hot and cold water and steam and water or other liquids. Powers Regulator Co., 2720 Greenwood Ave., Chicago, Ill.

C288 **General Radio Experimenter.** The August issue contains the following articles: New stroboscope for speed measurements; Color comparator; It's not the heat, it's the humidity; Type 107 direct-reading variable inductor. The September issue contains: An a-c. operated resistance-coupled amplifier; Decade condenser units. General Radio Co., 30 State St., Cambridge A, Mass.

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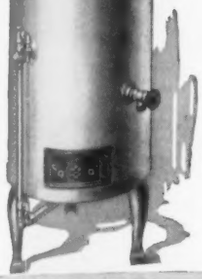

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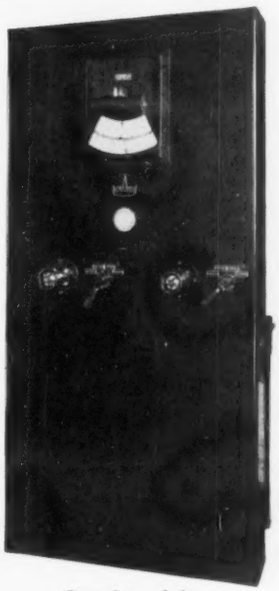

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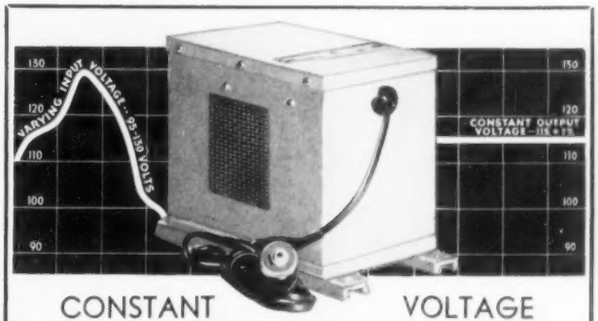

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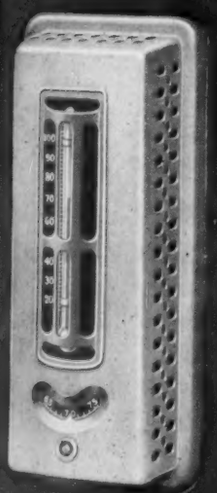

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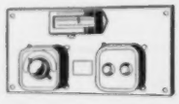

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Device utilized for effecting temperature or pressure control floats from one position to another. It does no mechanical work. It encounters no resistance or friction. Indications are accurate. There is no distortion. Catalog 4001.

Synchro Automatic Control Valve

Diaphragm operated, V port balanced type. For a given air pressure on the diaphragm top, position of the valve opening is the same, whether pressures are rising or falling. There is no friction loss. Response is instantaneous. Bulletin 938.

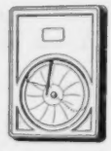
Thermo-Humidigraph

Or direct reading temperature and relative humidity recorder. Eliminates calculation and use of humidity tables. Eliminates personal errors. No water or fan required. Accurate below freezing temperature. Light portable case of corrosion-resisting materials. Bulletin 413.

Pyrometer Controller

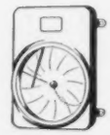
For ranges up to 3000°F. Clean non-arcing mercury-to-mercury electric contacts sealed in glass. No relays. Operating mechanism visible. Accessible telechron motor, mercury switches, terminal block. Simplified field inspection. Safe. Simple rugged working parts. Bulletin 389.

Recording Absolute Pressure Gauge



As easy to read as a clock. Furnishes continuous 24 hour record of absolute pressure automatically corrected for barometric variations and temperature changes. Supplied for ranges as low as 0 to 50 millimeters head of mercury column. Bulletin 401.

Fully Compensated Liquid-Filled Thermometer

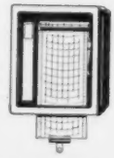


Charts accurately the temperatures to which the sensitive bulb is subjected. Neither a long length of connecting tubing nor disturbing temperature conditions along the tubing can impair its precision performance. Bulletin 1002.

Recording Voltmeter

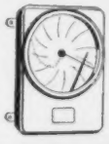
For furnishing continuous records of voltage fluctuations in transformers, primary voltages at power houses, secondary voltages at consumer's premises, voltage output from emergency storage batteries, incoming voltages at manufacturing plants. Catalog 1502-V.

Recording Ammeter



For furnishing continuous records of initial inrush and operating currents under variable load conditions. Used in connection with power and lighting circuits, substation buses, transformers, grounded neutral, motors, electric furnaces, ovens, signs. Bulletin 1502-A.

Recording Wattmeter



Records load conditions and power consumption of generators, motors, transformers, and electrically-driven machinery. Also records peak loads, central station output, input to mill, load of each building or department. Bulletin 1502-W.

BRISTOL'S

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